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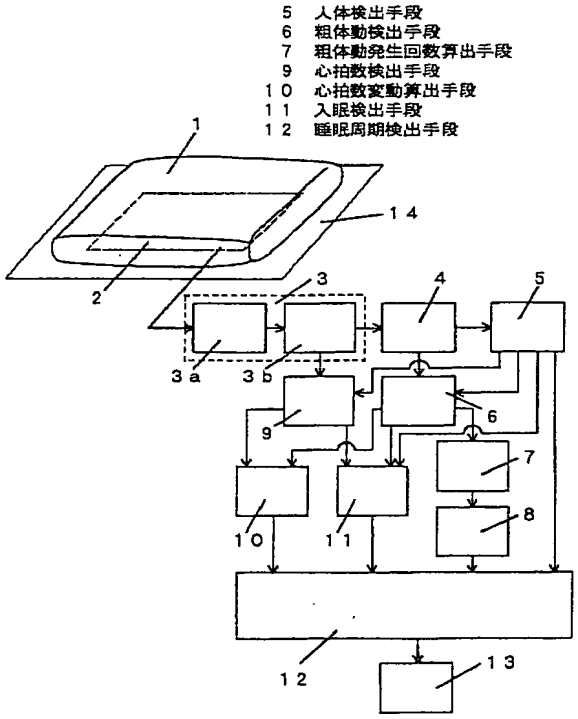
最終頁に続く

(54)【発明の名称】睡眠周期検出装置

(57)【要約】
【課題】　脳波等の採取をせずに人体の睡眠周期を検出する。
【解決手段】　敷布団１の下側に敷設した振動センサ２が検出した人体の振動から粗体動発生回数算出手段７によって粗体動発生回数を、また心拍数変動算出手段１０によって心拍数変動を検出し、睡眠周期検出手段１２でこれら２つの情報のうちどちらか単独または両方を使って睡眠周期を検出する。これにより、脳波や筋電図、眼球電図等の採取が不要で人体に電極等を取りつけることなく簡単に睡眠周期の概略を検出できる。



1

【特許請求の範囲】

【請求項１】　人体の動きである粗体動を検出する粗体動検出手段と、前記粗体動検出手段の検出結果から一定時間の粗体動発生回数を算出する粗体動発生回数算出手段と、前記粗体動発生回数算出手段の出力から前記人体の睡眠周期を検出する睡眠周期検出手段とを備えた睡眠周期検出装置。

【請求項２】　人体の心拍数を検出する心拍数検出手段と、前記心拍数検出手段の検出結果から心拍数の変動を算出する心拍数変動算出手段と、前記心拍数変動算出手段の出力から前記人体の睡眠周期を検出する睡眠周期検出手段とを備えた睡眠周期検出装置。

【請求項３】　人体の動きである粗体動を検出する粗体動検出手段と、前記人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、前記心拍数検出手段の検出結果と前記粗体動検出手段の検出結果とから前記人体の入眠を検出する入眠検出手段を備える睡眠周期検出装置。

【請求項４】　入眠検出手段は、心拍数検出手段の検出した心拍数の変化があらかじめ決められた閾値以下であり、かつ、粗体動検出手段が粗体動を検出しない状態を検出し、この状態があらかじめ決められた時間以上連続した場合に、人体が入眠したと判断する請求項３に記載の睡眠周期検出装置。

【請求項５】　入眠検出手段は、心拍数検出手段の検出した心拍数の変化があらかじめ決められた閾値以下であり、かつ、粗体動検出手段が粗体動を検出しない状態を検出し、この状態があらかじめ決められた時間以上連続した場合に、心拍数の変化があらかじめ決められた閾値以下になった時点、または、入眠検出の直前に粗体動が発生した時点から一定時間後の時点のうち、どちらか後の時点を持って入眠時刻とする請求項３に記載の睡眠周期検出装置。

【請求項６】　人体の動きである粗体動を検出する粗体動検出手段と、前記人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、前記粗体動検出手段の検出結果が一定時間粗体動を検出しないかまたは一定時間中の粗体動の回数があらかじめ決められた閾値以下であり、かつ、前記心拍数検出手段の検出結果の変動があらかじめ決められた閾値以下のとき深いノンレム睡眠と判断する睡眠周期検出装置。

【請求項７】　人体の動きである粗体動を検出する粗体動検出手段と、前記人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、

2

前記粗体動検出手段の検出結果における一定時間中の粗体動の発生回数があらかじめ決められた閾値以上であり、かつ、前記心拍数検出手段の検出結果の変動があらかじめ決められた閾値以上のときレム睡眠と判断する睡眠周期検出装置。

【請求項８】　人体の動きである粗体動を検出する粗体動検出手段と、前記人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから、前記人体の入眠、深いノンレム睡眠、レム睡眠のうち少なくとも一つを検出して睡眠周期の検出に用いる睡眠周期検出装置。

【請求項９】　請求項６または７記載の睡眠周期検出手段を備えた請求項８記載の睡眠周期検出装置。

【請求項１０】　人体の動きである粗体動を検出する粗体動検出手段と、前記粗体動検出手段の検出結果から粗体動発生回数を算出する粗体動発生回数算出手段と、人体の心拍数を検出する心拍数検出手段と、前記心拍数検出手段の検出結果から心拍数の変動を算出する心拍数変動算出手段と、前記粗体動発生回数算出手段の出力と前記心拍数変動算出手段の出力から前記人体の睡眠周期を検出する睡眠周期検出手段とを備えた睡眠周期検出装置。

【請求項１１】　粗体動発生回数算出手段は、少なくとも３０分以上の粗体動を検出して算出する請求項１または１０に記載の睡眠周期検出装置。

【請求項１２】　睡眠周期検出手段は、粗体動発生回数算出手段の出力から１時間から２時間周期の変動を検出して睡眠周期の検出に用いる請求項１、１０、１１のうちいずれか１つに記載の睡眠周期検出装置。

【請求項１３】　睡眠周期検出手段は、心拍数変動算出手段の出力から１時間から２時間周期の変動周期を検出して睡眠周期の算出に用いる請求項２または１０に記載の睡眠周期検出装置。

【請求項１４】　心拍数検出手段の検出結果のうち、粗体動検出手段が粗体動の発生を検出した時点の出力を除去した上で睡眠周期の検出に用いる請求項３ないし１０のうちすくなくとも１つに記載の睡眠周期検出装置。

【請求項１５】　人体を検出する人体検出手段を持ち、心拍数検出手段や粗体動検出手段は人体検出手段が人体を検出している場合にのみ、心拍数検出や粗体動検出を行なう請求項１ないし１４のうち少なくとも１つに記載の睡眠周期検出装置。

【請求項１６】　睡眠周期検出手段は、入眠検出手段を備え、前記入眠検出手段が入眠を検出後あらかじめ決められた時間以内に限り深いノンレム睡眠の検出を行なう請求項８に記載の睡眠周期検出装置。

【請求項１７】　睡眠周期検出手段は、入眠検出手段を

備え、前記入眠検出手段が入眠を検出後あらかじめ決められた時間以降に限りレム睡眠の検出を行なう請求項８に記載の睡眠周期検出装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、人体の睡眠周期を検出する睡眠周期検出装置に関するものである。

【０００２】

【従来の技術】従来、人体の睡眠状態を調べるために睡眠中の脳波、眼球電図、筋電図を測定して人体の睡眠深度を判定しており、上記３種の測定結果から４段階からなるノンレム睡眠と、レム睡眠および覚醒の６段階に分類されて人体の睡眠の状況を知るために用いられている。一般に人体の睡眠は脳の休息のためのノンレム睡眠と休息から覚醒させるための準備段階であるレム睡眠とが約１時間半の周期で繰り返されており、また、一晩の複数の睡眠周期では入眠後の最初の１、２周期は睡眠深度３、４の深いノンレム睡眠が長く現れる一方でレム睡眠はあまり出現せず、３周期以降になると睡眠深度３や４の深いノンレム睡眠はほとんどなくなり、逆にレム睡眠は長くなっていく。人体にとっては脳を十分に休息させるために深いノンレム睡眠が十分にあること、そして、睡眠からさわやかに目覚めるためにレム睡眠が周期的に出現することの両方が必要とされる。

【０００３】このような睡眠深度や睡眠周期の検出は一般に人体の脳波等を採取するために人体に電極を貼り付ける事が必要であり、準備が大変わずらわしく、また、睡眠をも妨げるものとなっていた。

【０００４】このような手間を省くために脳波、筋電図、眼球電図を用いることなく睡眠深度や睡眠周期を検出する方法が提案されている。たとえば、特開平５－９５９９３５号公報に開示されるものは、寝具に配置した圧電素子により人体の睡眠中の粗体動を検出し、粗体動の強度と粗体動の静止時間から睡眠深度を推定している。また、特開平８－１１２２７０号公報に開示されるものは、現在の心拍数の値とそれまでの心拍数の最低値との差分と粗体動からノンレム睡眠とレム睡眠とを判別している。さらに、特開２０００－２１５号公報に開示されるものは、寝具の下に配置されたエアマットの圧力を検出して睡眠中の人体の心拍数、呼吸数、粗体動を検出し、心拍数と呼吸数の変化から睡眠深度１および２の浅いノンレム睡眠と睡眠深度３および４の深いノンレム睡眠とを判別し、粗体動の発生頻度からノンレム睡眠とレム睡眠とを判別している。

【０００５】

【発明が解決しようとする課題】しかしながら、上記従来の睡眠周期検出装置では、主として粗体動の発生をレム睡眠の指標として用いているが、ノンレム睡眠でも四肢が動くなどの軽い粗体動も多く発生し、また、レム睡眠中の粗体動もノンレム睡眠との境界で粗体動が多く、レム睡眠が長く継続する場合はレム睡眠中であっても粗体動が比較的少なくなり、結果として両者の区別が困難になる場合があった。

【０００６】また、粗体動だけでなくレム睡眠時に変動が大きくなる心拍数を合わせて用いる場合も、粗体動を検出する圧力センサや振動センサの出力から心拍数を算出する構成の場合、粗体動の影響で心拍数を安定して検出できない場合も多く、その検出誤差をレム睡眠時の心拍数変動と誤認識してしまったり、入眠後最初の睡眠周期ではレム睡眠の出現時間が短かかったり出現しない場合もあり、レム睡眠の特徴のみを用いて睡眠周期を検出するには限界があった。

【０００７】本発明は、前記従来の課題を解決するもので、人体に電極等を取りつけることなく簡単にかつ確実に睡眠周期を検出できる睡眠周期検出装置を提供することを目的とする。

【０００８】

【課題を解決するための手段】本発明は上記課題を解決するために、粗体動検出手段が検出した睡眠中の粗体動から粗体動発生回数を算出し、心拍数検出手段が検出した睡眠中の心拍数の変動を算出して、粗体動発生回数または心拍数変動から人体の睡眠周期を決定する。また、粗体動検出手段の検出結果と心拍数検出手段の検出結果とから人体の入眠、深いノンレム睡眠、レム睡眠を検出して人体の睡眠周期を検出する。

【０００９】上記発明によれば、睡眠周期と相関する粗体動発生回数または心拍数変動周期とから人体の睡眠周期を決定するので、脳波や筋電図を採取するための電極を用いることなく簡単に睡眠周期に検出できる。また、粗体動と心拍数との２種類の睡眠中の特徴から入眠、深いノンレム睡眠、レム睡眠を検出できるので、簡単かつ正確に睡眠周期を検出できる。

【００１０】

【発明の実施の形態】本発明の請求項１にかかる睡眠周期検出装置は、人体の動きである粗体動を検出する粗体動検出手段と、前記粗体動検出手段の検出結果から一定時間の粗体動発生回数を算出する粗体動発生回数算出手段と、前記粗体動発生回数算出手段の出力から前記人体の睡眠周期を検出する睡眠周期検出手段とを備えた。

【００１１】そして、睡眠周期と相関がある粗体動の発生周期を求めて睡眠周期を検出するので、睡眠周期の概略を簡単に検出できる。

【００１２】本発明の請求項２にかかる睡眠周期検出装置は、人体の心拍数を検出する心拍数検出手段と、前記心拍数検出手段の検出結果から心拍数の変動を算出する心拍数変動算出手段と、前記心拍数変動算出手段の出力から前記人体の睡眠周期を検出する睡眠周期検出手段とを備えた。

【００１３】そして、睡眠周期と相関がある人体の心拍の変動周期を求めて睡眠周期を検出するので、睡眠周期

の概略を簡単に検出できる。

【００１４】本発明の請求項３にかかる睡眠周期検出装置は、人体の動きである粗体動を検出する粗体動検出手段と、前記人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、睡眠周期検出手段は、心拍数検出手段の検出結果と粗体動検出手段の検出結果とから前記人体の入眠を検出する入眠検出手段を備える。

【００１５】そして、粗体動と心拍数とを用いて入眠を検出するので、確実に入眠を検出できる。

【００１６】本発明の請求項４にかかる睡眠周期検出装置は、入眠検出手段は、心拍数検出手段の検出した心拍数の変化があらかじめ決められた閾値以下であり、かつ、粗体動検出手段が粗体動を検出しない状態を検出し、この状態があらかじめ決められた時間以上連続した場合に、人体が入眠したと判断する。

【００１７】そして、粗体動と心拍数の入眠時の特徴を用いて入眠を検出するので、確実に入眠を検出できる。

【００１８】本発明の請求項５にかかる睡眠周期検出装置は、入眠検出手段は、心拍数検出手段の検出した心拍数の変化があらかじめ決められた閾値以下であり、かつ、前記粗体動検出手段が粗体動を検出しない状態を検出し、その状態があらかじめ決められた時間以上連続した場合に、心拍数の変化があらかじめ決められた閾値以下になった時点、または、入眠検出の直前に粗体動が発生した時点から一定時間後の時点のうち、どちらか後の時点を持って入眠時刻とする。

【００１９】そして、粗体動と心拍数の入眠時の特徴を用いて入眠を検出し、これらの特徴のうち後に発生した特徴の時刻を持って入眠時刻とするので、確実に入眠時刻を決定できる。

【００２０】本発明の請求項６にかかる睡眠周期検出装置は、人体の動きである粗体動を検出する粗体動検出手段と、人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、前記粗体動検出手段の検出結果が一定時間粗体動を検出しないかまたは一定時間中の粗体動の回数があらかじめ決められた閾値以下であり、かつ、前記心拍数検出手段の検出結果の変動があらかじめ決められた閾値以下のとき深いノンレム睡眠と判断する。

【００２１】そして、粗体動と心拍数の深いノンレム睡眠時の特徴を用いて深いノンレム睡眠を検出するので、簡単に深いノンレム睡眠を検出できる。

【００２２】本発明の請求項７にかかる睡眠周期検出装置は、人体の動きである粗体動を検出する粗体動検出手段と、人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、前記粗体動検出手段の検出結果が一定時間中の粗体動の発生回数があらかじめ決められた閾値以上であり、かつ、前記心拍数検出手段の検出結果の変動があらかじめ決められた閾値以上のときレム睡眠と判断する。

【００２３】そして、粗体動と心拍数のレム睡眠時の特徴を用いてレム睡眠を検出するので、簡単に深いノンレム睡眠を検出できる。

【００２４】本発明の請求項８にかかる睡眠周期検出装置は、人体の動きである粗体動を検出する粗体動検出手段と、人体の心拍数を検出する心拍数検出手段と、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから前記人体の睡眠周期を検出する睡眠周期検出手段とを備え、前記睡眠周期検出手段は、前記粗体動検出手段の検出結果と前記心拍数検出手段の検出結果とから、前記人体の入眠、深いノンレム睡眠、レム睡眠のうち少なくとも一つを検出して睡眠周期の検出に用いる。

【００２５】そして、粗体動と心拍数から入眠、深いノンレム睡眠、レム睡眠を検出して睡眠周期を検出できるので、正確な睡眠周期を簡単に検出できる。

【００２６】本発明の請求項９にかかる睡眠周期検出装置は、請求項６または７記載の睡眠周期検出手段を備えた請求項８記載の睡眠周期検出装置である。

【００２７】そして粗体動と心拍数の深いノンレム睡眠時の特徴を用いて深いノンレム睡眠を検出するので、簡単に深いノンレム睡眠を検出できるので、粗体動と心拍数から入眠、深いノンレム睡眠、レム睡眠を検出して睡眠周期を検出でき正確な睡眠周期を簡単に検出できる。

【００２８】本発明の請求項１０にかかる睡眠周期検出装置は、人体の動きである粗体動を検出する粗体動検出手段と、前記粗体動検出手段の検出結果から粗体動発生回数を算出する粗体動発生回数算出手段と、人体の心拍数を検出する心拍数検出手段と、前記心拍数検出手段の検出結果から心拍数の変動を算出する心拍数変動算出手段と、前記粗体動発生回数算出手段の出力と前記心拍数変動算出手段の出力から前記人体の睡眠周期を検出する睡眠周期検出手段とを備えた。

【００２９】そして、粗体動発生回数と心拍変動発生周期という睡眠周期と相関のある２つの変動から睡眠周期を検出するので、簡単に睡眠周期を検出できる。

【００３０】また、本発明の請求項１１にかかる睡眠周期検出装置は、粗体動発生回数算出手段が、少なくとも３０分間以上の時間に発生した粗体動の数から粗体動発生回数を算出する。

【００３１】そして、睡眠深度が深い場合でも粗体動が発生する確率の高い時間間隔を用いて粗体動を検出し一回のデータとするので、間欠的な出力をアナログデータに効率的に変換できる。

【００３２】また、本発明の請求項１２にかかる睡眠周

期検出装置は、睡眠周期検出手段が粗体動発生回数算出手段の出力から１時間から２時間周期の変動を検出して睡眠周期とする。

【００３３】そして、一般に１時間半程度と言われる睡眠周期に相当する変動を検出して睡眠周期とするので、睡眠周期と同期する変動を確実に検出できる。

【００３４】また、本発明の請求項１３にかかる睡眠周期検出装置は、睡眠周期検出手段が、心拍数変動算出手段の出力から１時間から２時間周期の変動周期を検出して睡眠周期の算出に用いる。

【００３５】そして、心拍数変動のうち睡眠周期と同期する変動を検出して睡眠周期を決定するので、簡単かつ正確な睡眠周期を決定できる。

【００３６】また、本発明の請求項１４にかかる睡眠周期検出装置は、心拍数検出手段の検出結果のうち、粗体動検出手段が粗体動の発生を検出した時点の出力を除去した上で睡眠周期の検出に用いる。

【００３７】そして、睡眠周期の検出に粗体動発生のない時点のデータのみを用いるので、粗体動発生時の信頼性の低い心拍数を用いることなく正確に睡眠周期を検出できる。

【００３８】また、本発明の請求項１５にかかる睡眠周期検出装置は、人体を検出する人体検出手段を持ち、心拍数検出手段や粗体動検出手段は人体検出手段が人体を検出している場合にのみ、心拍数検出や粗体動検出を行なう。

【００３９】そして、人体が存在する場合にのみ心拍数や粗体動の検出を行なうので、人体以外からの一時的な振動に影響されることなく確実に睡眠周期を検出できる。

【００４０】また、本発明の請求項１６にかかる睡眠周期検出装置は、入眠検出手段を備え、前記入眠検出手段が入眠を検出後あらかじめ決められらた時間以内に限り深いノンレム睡眠の検出を行なう。

【００４１】そして、睡眠深度３または４の深いノンレム睡眠が出現する睡眠前期に限り深いノンレム睡眠の検出を行なうので、睡眠前期の深いノンレム睡眠を確実に検出できる。

【００４２】また、本発明の請求項１７にかかる睡眠周期検出装置は、入眠検出手段を備え、前記入眠検出手段が入眠を検出後あらかじめ決められらた時間以降に限りレム睡眠の検出を行なう。

【００４３】そして、一般にレム睡眠が多く出現する睡眠の後期に限りレム睡眠の検出を行なうので、睡眠の後期のレム睡眠を確実に検出できる。

【００４４】

【実施例】以下、本発明の実施例について図面を用いて説明する。

【００４５】（実施例１）図１は本発明の実施例１における睡眠周期検出装置のブロック図である。図中１は敷布団、２は敷布団１の下側に配置された人体の心拍や呼吸の細かな振動から寝返りや四肢の移動などの体の動きによる粗体動まで様々な振動を検出する振動センサ、３は振動センサの出力信号を増幅するとともに不要な周波数成分を除去する信号処理手段、４は信号処理手段３の出力の振幅を算出する振幅算出手段、５は振幅算出手段４の出力から敷布団１上の人体の存在を検出する人体検出手段、６は振幅算出手段４の出力から体の動きによる粗体動のみを検出する粗体動検出手段、７は粗体動検出手段の出力からその時点から３０分前までの粗体動発生回数を検出して出力する粗体動発生回数算出手段、８は粗体動発生回数算出手段７の出力から粗体動発生回数の変動を算出する粗体動発生回数変動算出手段、９は信号処理手段３の出力信号から心拍による変動成分を抽出して心拍数を検出する心拍数検出手段、１０は心拍数検出手段の出力から心拍数変動を算出する心拍数変動算出手段、１１は人体検出手段５の出力と粗体動検出手段６の出力と心拍数検出手段９の出力とから入眠を決定する入眠検出手段、１２は人体検出手段５の出力と粗体動発生回数変動算出手段８の出力と心拍数変動算出手段１０の出力と入眠検出手段１１の出力とから睡眠周期を決定する睡眠周期検出手段、１３は睡眠周期検出手段１２が検出した睡眠周期を表示する表示手段である。

【００４６】ここで振動センサ２は圧電素子を用い、機械的な振動が加えられた場合に振動の大きさに応じた電荷を発生するものであり、敷布団１の下側に配置される。また、振動センサ２の下は畳１４となっている。また、信号処理手段３は生体信号検出手段２の出力を増幅する増幅手段３ａと不要な周波数信号を除去するフィルター３ｂとからなっている。

【００４７】また、心拍数変動算出手段１０では、粗体動検出手段６の出力を用い粗体動発生時に検出された心拍数を心拍変動の算出に使用しないようにしており、また、粗体動検出手段７と心拍数検出手段９とは人体検出手段５の出力を用い人体が敷布団１上に存在しているときにのみ粗体動や心拍数の検出を行っている。

【００４８】上記構成の作用について説明する。図２に振幅算出手段４の出力図を示す。人体が敷布団１に着床し横になったり座ったりすると敷布団１の下側に配設された振動センサ２が振動して振動の大きさに応じた電圧を発生する。この発生信号には、図２に示すように、着床時には着床時の衝撃により一時的に大きな信号が現われる（Ａ）が、人体が安静にしていると人体の心拍や呼吸等の微体動による信号が継続して現われ（Ｂ）、寝返りをしたり腕や脚を動かす粗体動の場合には微体動の場合よりも大きな信号が一時的に出現する（Ｃ）。人体がいなければ出力信号は小さくなりゼロに近づく（Ｄ）。

【００４９】一方、敷布団１に物が置かれた場合は、物が置かれた瞬間には一時的に大きな信号が現われる（Ｅ）が、物には人体のような心拍や呼吸による細かな

微体動はないので出力信号は再びゼロに近づく（Ｆ）。また、人が敷布団１上を歩いて通過したような場合も物を置いた場合と同様になる。

【００５０】人体が存在する場合と存在しない場合とを分ける閾値として図に示すＶ１を用いることにより、振幅算出手段４の出力をこのＶ１と比較することにより人体の存在の有無を検出することができる。このような振動センサ２からの出力信号は、信号処理手段３の増幅手段３ａが増幅し、フィルター３ｂが不要な周波数成分を除去して振幅算出手段４と心拍数検出手段９とに出力している。

【００５１】振幅算出手段４は信号処理手段３の出力信号の振幅を算出して人体検出手段５と粗体動検出手段６とに出力している。人体検出手段５では図２に示すような在床時の信号の特徴に基づき敷布団１上の人体の存在の有無を判定している。この判定アルゴリズムを図３に示す。

【００５２】電源を入れる（ＳＴ１）とまずタイマーにＴ１をセットし（ＳＴ２）、「仮に人が存在」の判定からスタートする（ＳＴ３）。「仮に人が存在」とは、人が存在していることが疑われるが確実ではない状態であり、「不在」から「在」へ判定を変更する場合には必ずこの判定を経過させて、確実に存在すると判断してはじめて判定を「在」に変えている。これにより、ノイズや一時的な出力が発生しても「在」判定にならず、確実な人体検出が可能となる。スタート後タイマーを減じながら振幅算出手段４の出力をあらかじめ決められた閾値Ｖ１と比較し、Ｖ１以上の状態がタイマーが０になるまで連続すれば「在」に確定（ＳＴ６）し、タイマーが０になるまでにＶ１以下の状態に一度でもなれば「不在」に確定（ＳＴ１５）となる（ＳＴ４、ＳＴ５）。

【００５３】「在」が確定すると「仮に在」の時間も「在」とし（ＳＴ７、ＳＴ９）、「仮に不在」から「在」に確定された場合は「仮に不在」の時間も「在」に戻して（ＳＴ８）、振幅算出手段４の出力がＶ１以下になるのを検出するまでこの状態を維持する（ＳＴ１０）。

【００５４】振幅算出手段４の出力がＶ１以下になるとタイマーにＴ２をセットし（ＳＴ１１）、「仮に不在」として（ＳＴ１２）として不在判定を行なう。「在」から「不在」の判定は振幅算出手段４の出力がＶ１以下になる時間がＴ２以上連続した場合に「不在」に確定し（ＳＴ１５）、タイマーが０になるまでに一度でもＶ１以上になれば「在」に確定（ＳＴ６）する（ＳＴ１３、ＳＴ１４）。「仮に不在」から「不在」に確定となった場合は「仮に不在」となった時間も「不在」とし（ＳＴ１６、ＳＴ１８）、「仮に在」から「不在」に確定された場合は「仮に在」の時間も「不在」に戻して（ＳＴ１７）、振幅算出手段４の出力が入床時の人体の大きな体動を示すＶ２以上になるのを検出するまでこの状態を維持する（ＳＴ１９）。そして振幅算出手段４の出力がＶ１以上になった場合にタイマーにＴ１をセット（ＳＴ２０）して、再び「仮に在」として（ＳＴ３）として「在」か「不在」かの判定を行なう。

【００５５】この敷布団１上での人体の在、不在の判定は粗体動検出手段６と心拍数検出手段９と入眠検出手段１１と睡眠周期検出手段１２に出力される。粗体動検出手段６は、人体検出手段５が敷布団１上に人体が存在することを検出している場合に、振幅算出手段４の出力から敷布団１への人体の入床、離床や敷布団１上で寝返りなどの大きな粗体動のみを検出して粗体動発生回数算出手段７と心拍数変動算出手段１０と入眠検出手段１１に出力している。

【００５６】なお、粗体動検出手段６では、人体検出手段５が敷布団１上に人体がいること検出している場合にのみ人体の粗体動とするので、敷布団１上に人体が存在しない場合に敷布団１の近くに人が近づいたり、敷布団の上を歩いたりして振動センサ２から大きな出力が出た場合でも、これを粗体動と誤認識して誤った入眠検出や睡眠周期検出を行なうことを防止できる。

【００５７】心拍数検出手段９は、人体検出手段５が敷布団１上に人体が存在することを検出した場合に、信号処理手段３の出力からフィルターにより０．５Ｈｚから２Ｈｚまでの信号を抽出しこの信号の周期を求めて心拍数を算出し、心拍数変動算出手段１０と入眠検出手段１１に出力している。心拍数変動算出手段１０は心拍数検出手段９の５分間の分散を求めて心拍数の変動の大きさを算出し、睡眠周期検出手段１２に出力しているが、粗体動発生時は信号処理手段３の出力信号が大きくぶれて信号処理手段３の出力の周期性を用いて心拍数を算出している心拍数検出手段９の心拍数検出精度が低下してしまうことから、粗体動検出手段６の出力を用いて、粗体動が発生した時点の信号処理手段３の出力を用いて算出された心拍数のデータを取り除いた上で５分間の分散を算出し、粗体動による影響を受けない心拍数変動を算出して睡眠周期検出手段１２に出力している。ここでは、人体検出手段５が敷布団１上に人体がいること検出している場合にのみ人体の心拍数を検出するので、人体の信号のない状態で無理に心拍数を算出してしまうことがなく、これを用いて誤った入眠検出や睡眠周期検出を行なうことを防止できる。

【００５８】入眠検出手段１１は、人体検出手段５が敷布団１上に人体が存在することを検出している場合に、粗体動検出手段６の出力と心拍数検出手段９の出力とから敷布団１上の人体の入眠の検出を行っている。この入眠検出段の入眠の検出原理を図４を用いて説明する。図４（ａ）は１分間の心拍数、図４（ｂ）は粗体動の発生状況、図４（ｃ）は脳波等の結果から判定された睡眠段階である。なお、図４（ｃ）の縦軸の記号はＷは覚醒、Ｒはレム睡眠、１～４の数字はノンレム睡眠の睡眠深度

を示す。

【００５９】図中Ａは覚醒から入眠して睡眠深度１と判定されたが、５分後にまた覚醒と判定された部分であり、Ｂは覚醒から入眠して睡眠深度１から徐々に４まで進み深いノンレム睡眠に入った部分である。ここで図４（ａ）の心拍数の変化を見ると、Ａでは睡眠深度１と判定されるとともに心拍数が急速に低下し、５分後に再度覚醒と判定されると心拍数が再び上昇してＡの覚醒時の水準に戻っている。一方、Ｂでは入眠と同時に心拍数が低下するが、睡眠深度が１から４になっても入眠直後の心拍数が低下した後の心拍数の低い水準を維持している。このように入眠時の心拍数は覚醒から入眠に移行するときに急激に低下し、入眠状態から覚醒に戻ると急速に元のレベルに上昇する。

【００６０】また、図４（ｂ）を見ると、粗体動はＡの前とＢのあと睡眠深度が４からＲに変化したときに発生しており、入眠前後には粗体動の発生は見られない。これは、粗体動が入眠前後ではあまり発生せず、また、入眠直後には睡眠深度４の深いノンレム睡眠が発現しやすく睡眠深度が深くなると粗体動の発生はほとんどなくなることから、入眠直後は長時間にわたって粗体動が発生しないことが多い。

【００６１】そこで、本実施例では、（１）粗体動検出手段６の出力から粗体動の発生がＴ３時間以上発生しない場合で、かつ、（２）その間に心拍数がＣ１以上低下したことを検出し、（３）心拍数低下を検出後Ｔ４時間以上低下した水準を維持している場合に、敷布団１上の人体が入眠したと判定し、心拍数がＣ１以上低下した時点を持って入眠時刻としている。

【００６２】なお、入眠時の心拍数の変化は個人差があることがわかっているが、われわれの実験では覚醒から入眠または入眠から覚醒の変化のどちらかは明確に出ることが多いので心拍数の変化が長時間ない場合は覚醒が続いているかまたは入眠して睡眠状態になったかどちらかであると考えられる。どちらの状態であるかは粗体動の有無で判断できる。したがって、入眠時の心拍数変化が少なく上記のうち（２）の心拍数の低下が検出できない場合でも（１）と（３）から心拍数と粗体動とから確実に入眠を検出できる。ただし、この場合は入眠時刻は明確にならないので、入眠検出後、最後に体動が発生した時点からあらかじめ決められた一定時間Ｔ４後に入眠したとしている。なお、本実施例ではＴ４は１５分として設定している。

【００６３】粗体動発生回数算出手段７では、人体検出手段５の出力が人体が存在していることを検出している場合にその時点から３０分前までに発生した粗体動の回数をカウントしている。これは、睡眠中の粗体動の発生間隔が長いときで３０分以上となる場合があり、これは深いノンレム睡眠になっている場合に多くなるが、このような場合でもカウントの出力を極力ゼロとしないようにして出力の振り幅を大きくし周期性を明確にするためである。

【００６４】図５に粗体動発生回数算出手段７においてカウントする時間を変化させた場合の出力を示す。図５（ａ）は粗体動検出手段６が検出した粗体動、図５（ｂ）はカウントする時間が１５分間の場合、図５（ｃ）は３０分間の場合、図５（ｄ）は４５分間の場合である。図５（ｂ）で散見される粗体動回数０の平坦な部分が図５（ｃ）（ｄ）と時間が延びるに連れて徐々になくなり、図５（ｄ）では平坦な部分は存在しなくなるが、平坦な部分がなくなっていくと同時に長周期の波も明確になっていることがわかる。図５は一例ではあるが、これまでのわれわれの検討結果から３０分間以上体動回数をカウントすることが望ましいと思われる。これにより間欠的に発生する体動出力を効率よくアナログデータに変換できる。ただし、睡眠の周期は一般に約１時間３０分であるので、カウントする時間は１時間３０分よりも十分短いことが必要である。

【００６５】このように粗体動発生回数算出手段７が粗体動の長周期の変動を取り出し、さらに粗体動発生回数変動算出手段８が睡眠周期に相当する１時間から２時間の周期の変動を検出して睡眠周期検出手段１２に出力している。なお、粗体動発生回数変動算出手段の出力も、睡眠周期と相関するものであり、これのみでも睡眠周期の概略を知ることができる。

【００６６】睡眠周期検出手段１２は、入眠検出手段１１により人体の入眠が検出された後人体検出手段により離床したと判定されるまでの間の粗体動発生回数変動算出手段８と心拍数変動算出手段１０の出力とから睡眠周期を算出する。この算出の概念図６を用いて説明する。

【００６７】図６（ａ）は粗体動発生回数変動算出手段８の出力、（ｂ）は心拍数変動算出手段１０の出力、（ｃ）は本実施例の睡眠周期検出手段１２が検出した睡眠周期、（ｄ）は脳波等による睡眠深度の判定結果である。なお、図中、Ｗは覚醒、Ｒはレム睡眠、数字はノンレム睡眠の睡眠深度、ＮＲ１２は睡眠深度１または２に相当する浅いノンレム睡眠、ＮＲ３４は睡眠深度３または４に相当する深いノンレム睡眠をあらわす。

【００６８】まず、粗体動発生回数変動算出手段８の出力と心拍数変動算出手段１０の出力とから、深いノンレム睡眠に相当すると考えられる領域を抽出する。睡眠深度３または４の深いノンレム睡眠の場合、一定時間中の粗体動発生回数が多く、かつ、心拍数の変動が少ないという特徴があり、また、主として入眠から３時間以内に発生するので、深いノンレム睡眠の検出は（１）粗体動発生回数変動算出手段の出力がＭ１以下、（２）心拍数変動算出手段１０の出力がＣ２以下、（３）入眠検出手段１１が入眠を検出後３時間以内に発生、の３つの条件をともに満たす場合を睡眠深度３または４の深いノンレム睡眠であると判定する。

【００６９】次にレム睡眠の検出を行う。ここでは、レム睡眠では心拍数の変動がノンレム睡眠時より大きくなることと一定時間中の粗体動発生回数が多くなることを利用し、心拍数の変動から心拍数変動の大きな部分を抽出し、その部分の粗体動発生回数が閾値より大きい場合にレム睡眠を検出している。また、レム睡眠は入眠後３時間程度は出現時間が短かく、明確に心拍数変動として出現しない場合があるので、入眠後３時間以降にレム睡眠の検出をするのが望ましい。従って、ここでは、

（１）心拍数変動算出手段１０の出力がＣ３以上、

（２）粗体動発生回数変動算出手段の出力がＭ２以上、

（３）入眠検出手段１１が入眠を検出後３時間以降に発生、の３つの条件をともに満たす場合にレム睡眠であると判定している。

【００７０】なお、ここでは、心拍数変動算出手段１０の出力から１時間から２時間の周期の信号をフィルタによりろ波して取り出すことによりレム睡眠の周期に相当する変動を抽出したのちに上記のレム睡眠の検出を行っている。この変動のみでも、睡眠周期の特徴を反映するものであり、睡眠周期の簡単な指標として用いることも可能である。

【００７１】このように抽出された入眠から３時間以内の深いノンレム睡眠の部分と入眠から３時間以降のレム睡眠の部分を一体化することにより図６（ｃ）のように睡眠周期を求めることができる。これを図６（ｄ）の脳波等による睡眠深度判定と比較すると細かい点に違いはあるが、概略は適合していることがわかる。

【００７２】なお、この変動を評価して睡眠周期として正しいか否かを判定してもよい。たとえば、（１）得られた睡眠周期が１．５時間から２時間の規則正しい周期で繰り返されているか、（２）粗体動発生回数変動と相関しているか（３）心拍数変動周期と相関しているかの３点に基づいて判定できる。（１）では睡眠周期を周波数分析し、パワースペクトル密度を用い周期が１．５時間から２時間に相当する周波数帯のピークがあらかじめ決められた閾値Ｐ１と比較してＰ１以上の場合に１．５時間から２時間の規則正しい周期で繰り返されていると判定できる。また、（２）、（３）についてはそれぞれの波形と相互相関を算出し、相互相関係数の値があらかじめ決められた閾値Ｒ１、Ｒ２以上の場合に相関があるとそれぞれ判定できる。なお、この判定ですべてが正しくないと判明したときは再度各閾値を変更して睡眠周期の算出をやり直すことも可能である。これにより正確な睡眠周期の検出を実現できる。

【００７３】また、粗体動発生回数変動算出手段の変動波形と心拍数変動算出手段の変動波形を組み合わせてより正確な睡眠周期を求めることもできる。粗体動発生回数変動算出手段の出力では睡眠前半のノンレム睡眠の特徴が明確になるが後半の睡眠周期が不安定となり、心拍数変動算出手段の出力では、逆にレム睡眠の影響で前半より広範の方が明確な変動が現れやすいので、両者の長所を有効に活用してより正確な睡眠周期の概略を得ることができる。

【００７４】このように本実施例の睡眠周期検出装置は、睡眠周期と相関がある粗体動または心拍数変動の発生周期を求めてどちらか単独または両者を組み合わせて睡眠周期を検出するので、睡眠周期の概略を簡単に検出できる。

【００７５】また、本実施例の睡眠周期検出装置は、粗体動と心拍数から入眠時、深いノンレム睡眠、および、レム睡眠の特徴を用いてそれぞれの睡眠段階を検出できるので正確な睡眠周期を求めることができる。

【００７６】また、本実施例の睡眠周期検出装置は、一般に１時間半程度と言われる睡眠周期に相当する変動を検出して睡眠周期とするので、睡眠周期と同期する変動を確実に検出できる。

【００７７】なお、本実施例では生体の支持手段として敷布団を用いているが、ベッドや座席に使用するものでもよい。

【００７８】また、本実施例では信号処理手段は増幅手段とフィルターとからなっているが、増幅手段は生体信号検出手段の感度がよく出力が十分取れる場合は必ずしも必要ではなく、フィルターも不要な信号成分の大きさが生体信号より十分小さい場合は不要にできる。

【００７９】また、本実施例では、判定手段においてＶ１、Ｔ１など時間や検出値などをあらかじめ決められた閾値と比較して睡眠周期や敷布団上での在／不在を判定しているが、これらの閾値は実際に多数の人で出力を確認しこれらのデータから統計的に求めた最適値を使用している。なお、この閾値は一定値を用いてもよいが、心拍数や粗体動の検出を行ないながら都度変更させるものでももちろんよい。

【００８０】また、本実施例では、一つの振動センサを用いて敷布団上の人体の粗体動と心拍数を検出しているが、それぞれ別の専用の検出手段を用いる構成でもよい。また、心拍数のみでなく呼吸数も求め、睡眠周期の検出に用いることも可能である。

【００８１】また、本実施例では振動センサを用いて粗体動と心拍数の検出を行なっているがたとえばレーザー変異計などにより非接触で体の動きといった粗体動や、呼吸、心拍活動に起因する人体の腹部の上下動を検出するものや、ｃｃｄカメラなどを用い非接触で布団上の人体の呼吸や心拍活動に起因する微妙な変化や体の大きな動きを検出するものを用いてもよい。

【００８２】また、本実施例では振動センサを敷布団の下に敷いているが、振動センサの下に更にスポンジ等のクッションなどを配置すると振動に対する出力を大きくできる。特にＰＶＤＦ（ポリ弗化ビリニデン）など可とう性の圧電素子を振動センサとして用いる場合は有効である。

【００８３】また、本実施例では、深いノンレム睡眠の検出を入眠から３時間以内に限って行なっているが、深いノンレム睡眠の出現が入眠後３時間以内に多く見られるという一般的な所見からこの数値を設定している。しかし、入眠後３時間以降でも出現することはあり、従ってこの検出を必ずしも３時間以内に限定する必要はない。また、同様に、レム睡眠の検出を入眠後３時間以降に限っているが、こちらも必ずしも３時間以降に限定する必要はない。さらに、本実施例では、深いノンレム睡眠の検出とレム睡眠の検出の時間領域は重複してないが両者の検出領域が重なってもまったくかまわない。

【００８４】また、本実施例では、心拍数変動算出手段は５分間の心拍数から分散を算出して出力しているが、変動の算出に用いる時間は１分から１０分程度の間であればよく、５分に限定するものではない。また、変動の算出も分散を用いず標準偏差など変動の大きさを算出できる計算方法であればいかなる計算方法を用いてよい。

【００８５】また、本実施例では、体動発生回数算出手段の出力や心拍数変動算出手段の出力から１時間から２時間周期の変動成分を取り出して睡眠周期検出に用いているが、これは、睡眠周期が一般に１時間半程度の周期をもって変動し、しかも個人によりまたその時々の状態によって変化するため、１時間から２時間までの周期の変動を検出できればこのような状態の変化にも十分に対応できるからである。しかし、必ずしも１時間から２時間の変動成分をすべて取り出す必要はないし、体動発生回数算出手段の出力や心拍数変動算出手段の出力を単に移動平均するなどしてノイズ成分を除去したものでも十分に睡眠周期検出に利用できる。

【００８６】上記の実施例に述べたように、本発明の睡眠周期検出装置は脳波や筋電図、眼球電図を採取することなく人体の睡眠周期を検出できる。これを用いることにより、不眠症患者の睡眠状態の把握や、不眠を訴える人の実際の睡眠状況の把握が簡単に行なえる。また、睡眠周期や睡眠の時間帯からサーカディアンリズムなどの人に固有の生活リズムを割り出すことも可能であり、生活リズムが乱れがちな若者や高齢者に対する適切な生活の指導や活力ある生活の実現等に大いに役立てることができる。

【００８７】

【発明の効果】以上、実施例で説明したように本発明によれば、脳波や筋電図、眼球電図を採取することなく人体の睡眠周期を検出できる。これを用いることにより、不眠症患者の睡眠状態の把握や、不眠を訴える人の実際の睡眠状況の把握が簡単に行なえる。

【図面の簡単な説明】

【図１】本発明の実施例１における睡眠周期検出装置のブロック図

【図２】同装置の振幅算出手段の出力図

【図３】同装置の人体検出手段の人体検出アルゴリズムのフローチャート

【図４】（ａ）同装置の入眠検出時の心拍数検出手段の出力図

（ｂ）同装置の入眠検出時の粗体動検出手段の出力図

（ｃ）入眠検出時の脳波等を用いて検出した睡眠段階図

【図５】（ａ）同装置の粗体動検出手段の出力図

（ｂ）同装置の粗体動発生回数算出手段の出力図

（ｃ）同装置の粗体動発生回数算出手段の出力図

（ｄ）同装置の粗体動発生回数算出手段の出力図

【図６】（ａ）同装置の粗体動発生回数変動算出手段の出力図

（ｂ）同装置の心拍数変動算出手段の出力図

（ｃ）同装置の睡眠周期検出手段の出力図

（ｄ）脳波等を用いて検出した睡眠段階図

【符号の説明】

５　人体検出手段

６　粗体動検出手段

７　粗体動発生回数算出手段

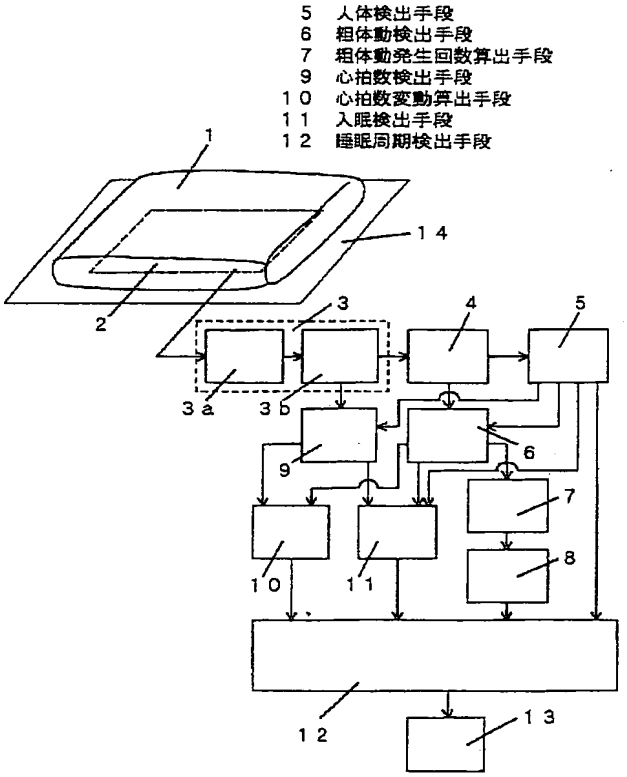
９　心拍数検出手段

１０　心拍数変動算出手段

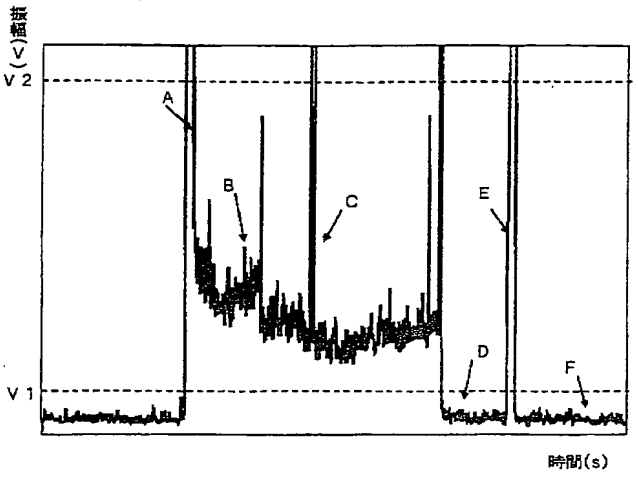
１１　入眠検出手段

１２　睡眠周期検出手段

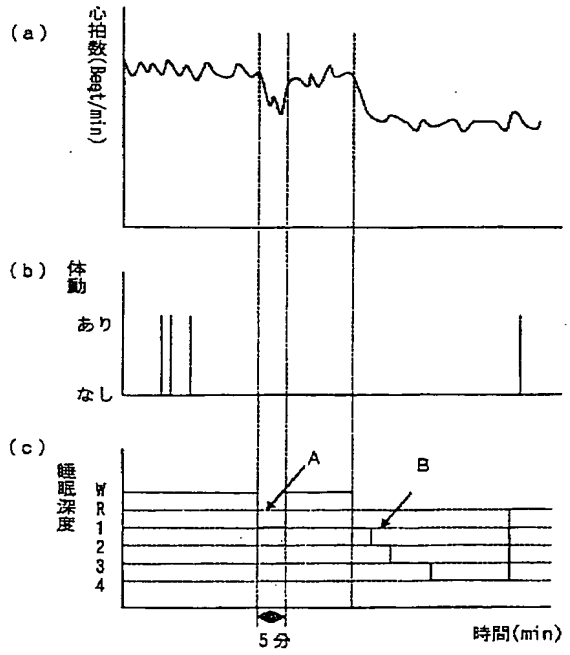
【図１】


5　人体検出手段
6　粗体動検出手段
7　粗体動発生回数算出手段
9　心拍数検出手段
10　心拍数変動算出手段
11　入眠検出手段
12　睡眠周期検出手段
1
14
2
3
4
5
3a
3b
9
6
7
8
10
11
12
13

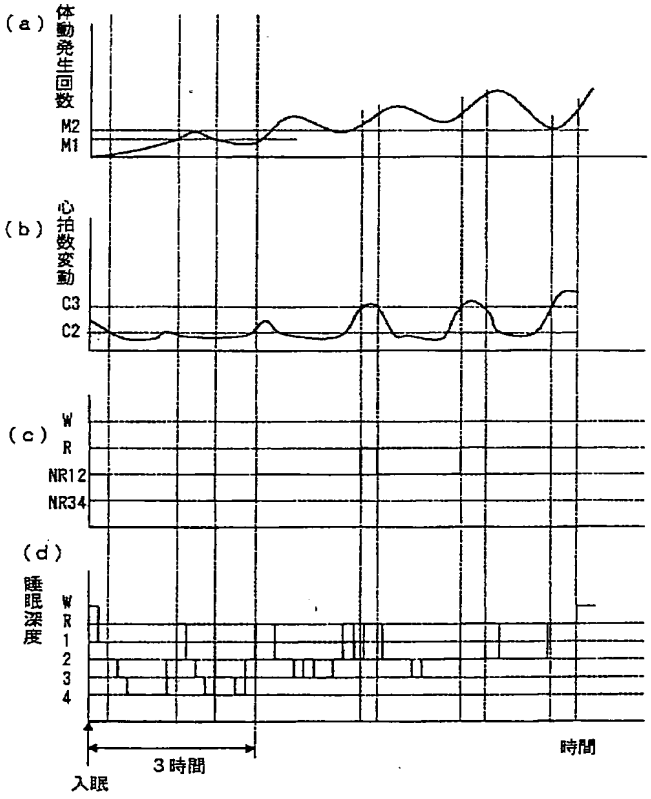
【図２】


振幅(V)
V2
V1
A
B
C
D
E
F
時間(s)

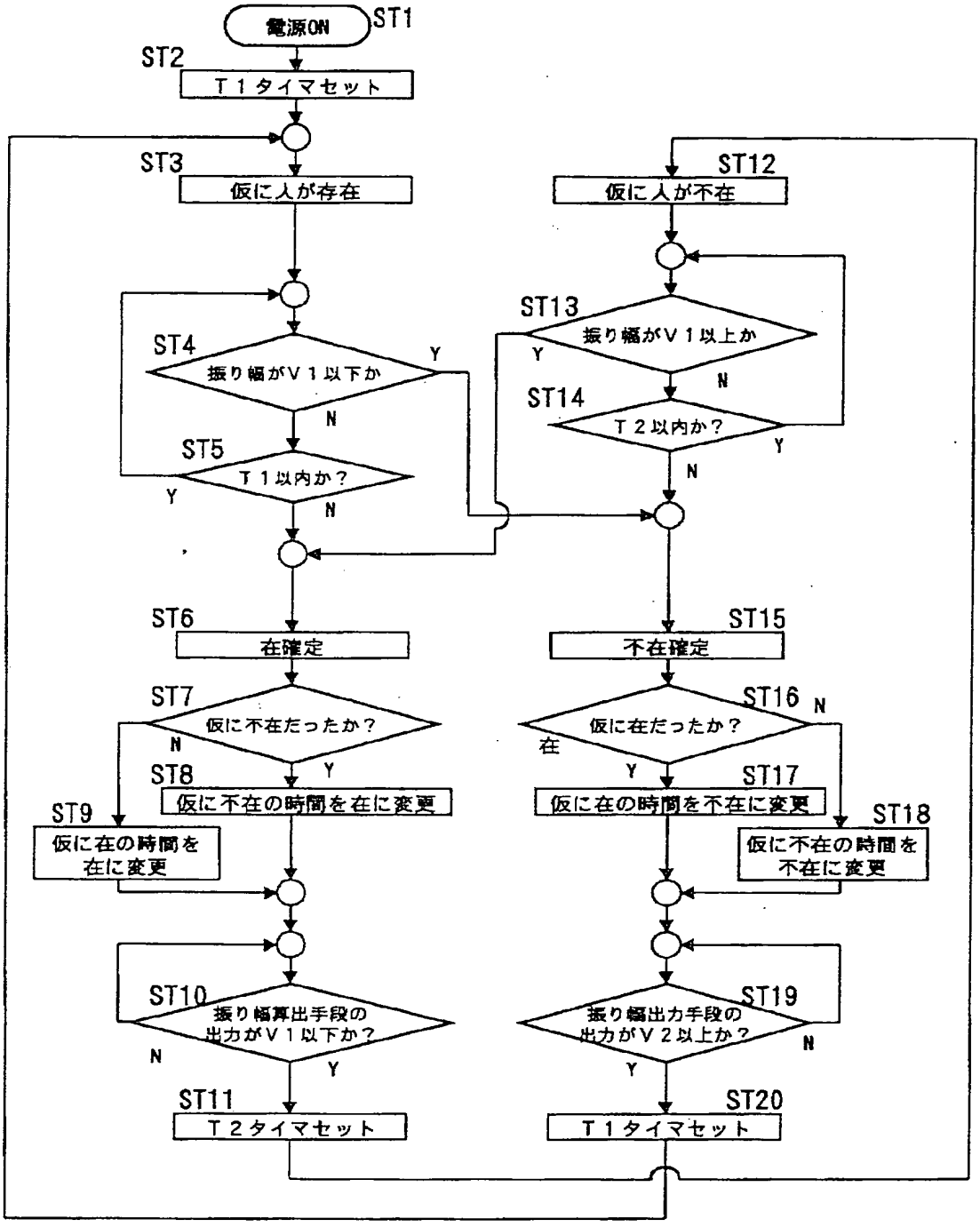
【図４】


(a)
心拍数(Beat/min)
(b)
体動
あり
なし
(c)
睡眠深度
W
R
1
2
3
4
A
B
5分
時間(min)

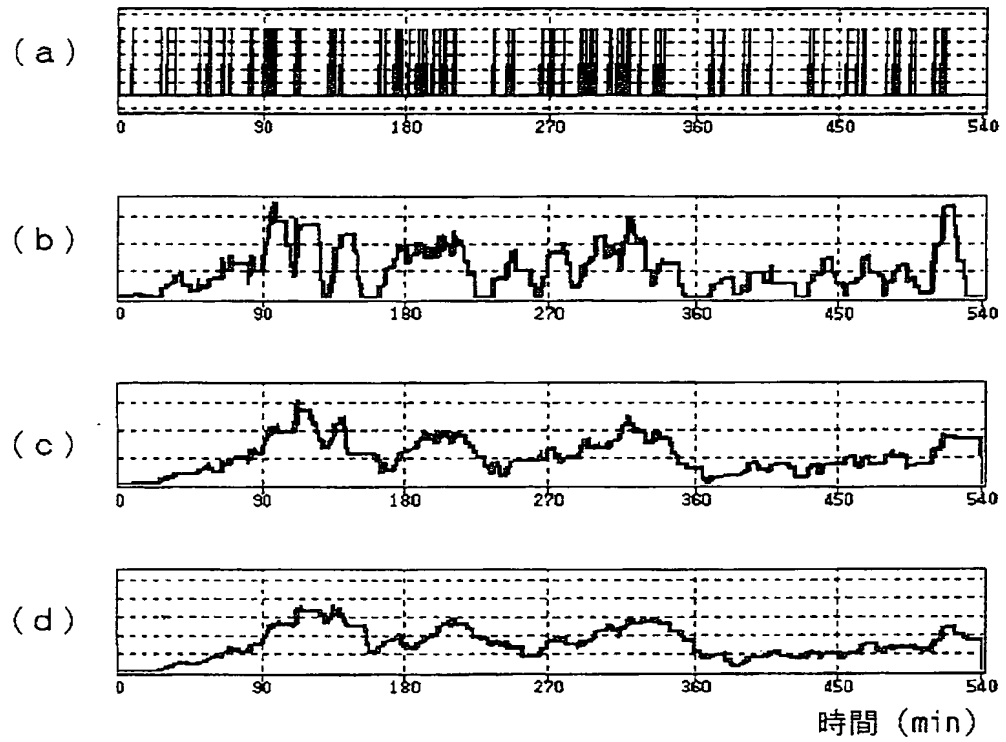
【図６】


(a)
体動発生回数
M2
M1
(b)
心拍数変動
C3
C2
(c)
W
R
NR12
NR34
(d)
睡眠深度
W
R
1
2
3
4
3時間
入眠
時間

【図３】


電源ON
ST1
ST2
Ｔ１タイマセット
ST3
仮に人が存在
ST4
振り幅がＶ１以下か
Y
N
ST5
Ｔ１以内か？
Y
N
ST6
在確定
ST7
仮に不在だったか？
N
Y
ST8
仮に不在の時間を在に変更
ST9
仮に在の時間を
在に変更
ST10
振り幅算出手段の
出力がＶ１以下か？
N
Y
ST11
Ｔ２タイマセット
ST12
仮に人が不在
ST13
振り幅がＶ１以上か
Y
N
ST14
Ｔ２以内か？
Y
N
ST15
不在確定
ST16
仮に在だったか？
在
N
Y
ST17
仮に在の時間を不在に変更
ST18
仮に不在の時間を
不在に変更
ST19
振り幅出力手段の
出力がＶ２以上か？
Y
N
ST20
Ｔ１タイマセット

【図５】



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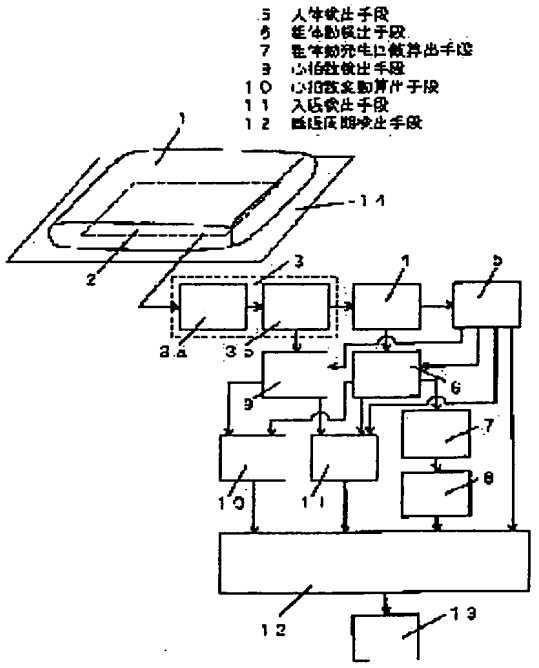
(54) SLEEP CYCLE DETECTOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a means for detecting a sleep cycle of a living body without collecting EEG, or the like.

SOLUTION: An approximate incidence of body movements is detected by a method 7 that calculates the approximate incidence of body movements from a somatic vibration detected by a vibration sensor 2 installed in the lower side of a mattress 1 and heart rate changes are detected by a method 10 that detects the sleep cycle before the sleep cycle is detected by using either one of these methods or both of them using a sleeve cycle detector 12, when an outline of the sleep cycle can easily be detected without obtaining EEG, EMG, EOG, or the like, or installing an electrode, or the like, in a living body.



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[Date of extinction of right]

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3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Sleep period detection equipment equipped with a rough body motion detection means detect the rough body motion which is a motion of the body, a count calculation means of rough body motion generating compute the count of rough body motion generating of fixed time amount from the detection result of said rough body motion detection means, and a sleep period detection means detect the sleep period of said body from the output of said count calculation means of rough body motion generating.
[Claim 2] Sleep period detection equipment equipped with a heart rate detection means to detect the heart rate of the body, a heart rate fluctuation calculation means to compute fluctuation of a heart rate from the detection result of said heart rate detection means, and a sleep period detection means to detect the sleep period of said body from the output of said heart rate fluctuation calculation means.
[Claim 3] A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of said body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means Sleep period detection equipment equipped with a hypnagogic detection means to detect hypnagogic [of said body] from the detection result of said heart rate detection means, and the detection result of said rough body motion detection means.
[Claim 4] A hypnagogic detection means is sleep period detection equipment according to claim 3 judged that the body carried out hypnagogic when it continues beyond the time amount with which are below the threshold change of the heart rate which the heart rate detection means detected was beforehand decided to be, and detected the condition that a rough body motion detection means did not detect a rough body motion, and this condition was beforehand decided to be.
[Claim 5] A hypnagogic detection means is below the threshold change of the heart rate which the heart rate detection means detected was beforehand decided to be. And when it continues beyond the time amount with which detected the condition that a rough body motion detection means did not detect a rough body motion, and this condition was beforehand decided to be Sleep period detection equipment according to claim 3 made into hypnagogic time of day with the time of which or the back the time of change of a heart rate becoming below the threshold decided beforehand, or just before hypnagogic detection from the time of a rough body motion occurring while at the time after fixed time amount.
[Claim 6] A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of said body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means It is below the threshold with which the detection result of said rough body motion detection means did not detect a fixed time amount rough body motion, or the count of the rough body motion in fixed time amount was beforehand decided to be. And sleep period detection equipment judged to be deep non-REM sleep when fluctuation of the detection result of said heart rate detection means is below the threshold decided beforehand.
[Claim 7] A rough body motion detection means to detect the rough body motion which is a motion

of the body, and a heart rate detection means to detect the heart rate of said body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means Sleep period detection equipment which is beyond the threshold the count of generating of the rough body motion in fixed time amount in the detection result of said rough body motion detection means was beforehand decided to be, and is judged to be REM sleep when it is beyond the threshold fluctuation of the detection result of said heart rate detection means was beforehand decided to be.

[Claim 8] A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of said body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means Sleep period detection equipment which detects at least one of hypnagogic [of said body], deep non-REM sleep, and REM sleep, and is used for detection of a sleep period from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means.

[Claim 9] Sleep period detection equipment [equipped with the sleep period detection means according to claim 6 or 7] according to claim 8.

[Claim 10] A rough body motion detection means to detect the rough body motion which is a motion of the body, and a count calculation means of rough body motion generating to compute the count of rough body motion generating from the detection result of said rough body motion detection means, A heart rate detection means to detect the heart rate of the body, and a heart rate fluctuation calculation means to compute fluctuation of a heart rate from the detection result of said heart rate detection means, Sleep period detection equipment equipped with a sleep period detection means to detect the sleep period of said body from the output of said count calculation means of rough body motion generating, and the output of said heart rate fluctuation calculation means.

[Claim 11] The count calculation means of rough body motion generating is sleep period detection equipment according to claim 1 or 10 which detects and computes the rough body motion for 30 minutes or more at least.

[Claim 12] A sleep period detection means is sleep period detection equipment of any one publication among claims 1, 10, and 11 which detect fluctuation of 1 hour to two time periods from the output of the count calculation means of rough body motion generating, and are used for detection of a sleep period.

[Claim 13] A sleep period detection means is sleep period detection equipment according to claim 2 or 10 which detects the fluctuation period of 1 hour to two time periods from the output of a heart rate fluctuation calculation means, and is used for calculation of a sleep period.

[Claim 14] It is [claim 3 used for detection of a sleep period after removing the output at the time of a rough body motion detection means detecting generating of a rough body motion among the detection results of a heart rate detection means thru/or] sleep period detection equipment of at least one publication among 10.

[Claim 15] It is [claim 1 which has a body detection means to detect the body, and performs heart rate detection and rough body motion detection only when, as for a heart rate detection means or a rough body motion detection means, the body detection means has detected the body thru/or] sleep period detection equipment of at least one publication among 14.

[Claim 16] A sleep period detection means is sleep period detection equipment according to claim 8 which it has a hypnagogic detection means, and said hypnagogic detection means is decided beforehand after detecting hypnagogic, restricts within **** time amount, and detects deep non-REM sleep.

[Claim 17] A sleep period detection means is sleep period detection equipment according to claim 8 which it has a hypnagogic detection means, and said hypnagogic detection means is decided beforehand after detecting hypnagogic, restricts after **** time amount, and detects REM sleep.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the sleep period detection equipment which detects the sleep period of the body.
[0002]
[Description of the Prior Art] The electroencephalogram under sleep in order to investigate the sleep state of the body conventionally, the eye ball lightning Fig., and the electromyogram were measured, and the sleep depth of the body is judged, and it is used in order to be classified into six steps of the non-REM sleep which consists of four steps, REM sleep, and recovery from the three above-mentioned sorts of measurement results and to know the situation of sleep of the body. Generally the REM sleep which is a preparation phase for awaking sleep of the body from the non-REM sleep for a cerebral rest and rest is repeated with the period for about 1 hour and a half. Moreover, if REM sleep seldom appears but it becomes two or more overnight sleep periods after 3 periods while, as for 1 of the beginning after hypnagogic, and 2 period, the deep non-REM sleep of the sleep depth 3 and 4 appears for a long time, most of the sleep depth 3 or the deep non-REM sleep of 4 is lost, and REM sleep becomes long conversely. For the body, since non-REM sleep deep in order to fully rest a brain fully wakes up freshly from a certain thing and sleep, it is needed both for REM sleep to appear periodically.
[0003] Detection of such sleep depth or a sleep period needed to stick an electrode on the body, in order to extract the electroencephalogram of the body etc. generally, its preparation was very troublesome, and it had also barred sleep.
[0004] The method of detecting sleep depth and a sleep period is proposed without using an electroencephalogram, an electromyogram, and an eye ball lightning Fig., in order to save such time and effort. For example, what is indicated by JP,5-959935,A detected the rough body motion under sleep of the body by the piezoelectric device arranged on bedding, and presumes sleep depth from the quiescence time amount of the reinforcement of a rough body motion, and a rough body motion. Moreover, what is indicated by JP,8-112270,A has distinguished non-REM sleep and REM sleep from the difference and the rough body motion of the value of a current heart rate, and the minimum value of the heart rate till then. Furthermore, what is indicated by JP,2000-215,A detected the pressure of the air mat arranged under bedding, detected the heart rate of the body under sleep, the respiration rate, and the rough body motion, distinguished the shallow non-REM sleep of the sleep depth 1 and 2, and the deep non-REM sleep of the sleep depth 3 and 4 from change of a heart rate and a respiration rate, and has distinguished non-REM sleep and REM sleep from the occurrence frequency of a rough body motion.
[0005]
[Problem(s) to be Solved by the Invention] However, although generating of a rough body motion is mainly used as an index of REM sleep with the above-mentioned conventional sleep period detection equipment Many light rough body motions, like the limbs move also by non-REM sleep were also generated, and the rough body motion in REM sleep also had many rough body motions on the boundary with non-REM sleep, and when REM sleep continued for a long time, even if it was among REM sleep, the rough body motion decreased comparatively, and there was a case where both distinction became difficult as a result.

[0006] Moreover, not only a rough body motion but when doubling and using the heart rate to which fluctuation becomes large at the time of REM sleep In the case of a configuration of computing a heart rate from the output of the pressure sensor and sway sensor which detect a rough body motion Under the effect of a rough body motion, it is stabilized and a heart rate cannot be detected in many cases. Incorrect-recognize the detection error to be heart rate fluctuation at the time of REM sleep, or The appearance time of REM sleep may not carry out a short ********** appearance the first sleep period after hypnagogic, and there was a limitation in detecting a sleep period only using the description of REM sleep.
[0007] This invention solves said conventional technical problem, and it aims at offering the sleep period detection equipment which can detect a sleep period simply and certainly, without attaching an electrode etc. in the body.
[0008]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, this invention computes the count of rough body motion generating from the rough body motion under sleep which the rough body motion detection means detected, computes fluctuation of the heart rate under sleep which the heart rate detection means detected, and determines the sleep period of the body from the count of rough body motion generating, or heart rate fluctuation. Moreover, hypnagogic [of the body], deep non-REM sleep, and REM sleep are detected from the detection result of a rough body motion detection means, and the detection result of a heart rate detection means, and the sleep period of the body is detected.
[0009] Since the sleep period of the body is determined from the count of rough body motion generating or heart rate fluctuation period correlated with a sleep period according to the above-mentioned invention, it can detect to a sleep period easily, without using the electrode for extracting an electroencephalogram and an electromyogram. Moreover, since hypnagogic, deep non-REM sleep, and REM sleep are detectable from the description under two kinds of sleep with a rough body motion and a heart rate, a sleep period is correctly [simply and] detectable.
[0010]
[Embodiment of the Invention] The sleep period detection equipment concerning claim 1 of this invention had a rough body motion detection means detect the rough body motion which is a motion of the body, a count calculation means of rough body motion generating compute the count of rough body motion generating of fixed time amount from the detection result of said rough body motion detection means, and a sleep period detection means detect the sleep period of said body from the output of said count calculation means of rough body motion generating.
[0011] And since a sleep period is detected in quest of a sleep period and the generating period of a rough body motion with correlation, the outline of a sleep period is easily detectable.
[0012] The sleep period detection equipment concerning claim 2 of this invention was equipped with a heart rate detection means to detect the heart rate of the body, a heart rate fluctuation calculation means to compute fluctuation of a heart rate from the detection result of said heart rate detection means, and a sleep period detection means to detect the sleep period of said body from the output of said heart rate fluctuation calculation means.
[0013] And since a sleep period is detected in quest of a sleep period and the fluctuation period of the heartbeat of the body with correlation, the outline of a sleep period is easily detectable.
[0014] The sleep period detection equipment concerning claim 3 of this invention A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of said body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means, and a sleep period detection means is equipped with a hypnagogic detection means to detect hypnagogic [of said body] from the detection result of a heart rate detection means, and the detection result of a rough body motion detection means.
[0015] And since it detects hypnagogic using a rough body motion and a heart rate, hypnagogic is certainly detectable.
[0016] A hypnagogic detection means is below the threshold change of the heart rate which the heart rate detection means detected was beforehand decided to be, and the sleep period detection

equipment concerning claim 4 of this invention detects the condition that a rough body motion detection means does not detect a rough body motion, and when it continues beyond the time amount this condition was beforehand decided to be, it judges that the body carried out hypnagogic.
[0017] And since it detects hypnagogic using the description at the time of a rough body motion and hypnagogic [of a heart rate], hypnagogic is certainly detectable.
[0018] The sleep period detection equipment concerning claim 5 of this invention A hypnagogic detection means is below the threshold change of the heart rate which the heart rate detection means detected was beforehand decided to be. And when it continues beyond the time amount with which detected the condition that said rough body motion detection means did not detect a rough body motion, and the condition was beforehand decided to be From the time of a rough body motion occurring, while at the time after fixed time amount, it considers as hypnagogic time of day with the time of which or the back the time of change of a heart rate becoming below the threshold decided beforehand, or just before hypnagogic detection.
[0019] And hypnagogic is detected using the description at the time of a rough body motion and hypnagogic [of a heart rate], and since it considers as hypnagogic time of day with the time of day of the description behind generated among these descriptions, hypnagogic time of day can be determined certainly.
[0020] The sleep period detection equipment concerning claim 6 of this invention A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of the body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means When it is below the threshold with which are below the threshold with which the detection result of said rough body motion detection means did not detect a fixed time amount rough body motion, or the count of the rough body motion in fixed time amount was beforehand decided to be, and fluctuation of the detection result of said heart rate detection means was beforehand decided to be, it is judged as deep non-REM sleep.
[0021] And since deep non-REM sleep is detected using the description at the time of non-REM sleep with deep rough body motion and heart rate, deep non-REM sleep is easily detectable.
[0022] The sleep period detection equipment concerning claim 7 of this invention A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of the body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means When the detection result of said rough body motion detection means is beyond the threshold with which are beyond the threshold the count of generating of the rough body motion in fixed time amount was beforehand decided to be, and fluctuation of the detection result of said heart rate detection means was beforehand decided to be, it judges it as REM sleep.
[0023] And since REM sleep is detected using the description at the time of the REM sleep of a rough body motion and a heart rate, deep non-REM sleep is easily detectable.
[0024] The sleep period detection equipment concerning claim 8 of this invention A rough body motion detection means to detect the rough body motion which is a motion of the body, and a heart rate detection means to detect the heart rate of the body, It has a sleep period detection means to detect the sleep period of said body from the detection result of said rough body motion detection means, and the detection result of said heart rate detection means. Said sleep period detection means From the detection result of said rough body motion detection means, and the detection result of said heart rate detection means, at least one of hypnagogic [of said body], deep non-REM sleep, and REM sleep is detected, and it uses for detection of a sleep period.
[0025] And since hypnagogic, deep non-REM sleep, and REM sleep are detected from a rough body motion and a heart rate and a sleep period can be detected, an exact sleep period is easily detectable.
[0026] The sleep period detection equipment concerning claim 9 of this invention is sleep period detection equipment [equipped with the sleep period detection means according to claim 6 or 7] according to claim 8.
[0027] And since deep non-REM sleep is detected using the description at the time of non-REM

sleep with deep rough body motion and heart rate and deep non-REM sleep is easily detectable, hypnagogic, deep non-REM sleep, and REM sleep can be detected from a rough body motion and a heart rate, a sleep period can be detected, and an exact sleep period can be detected easily.
[0028] The sleep period detection equipment concerning claim 10 of this invention A rough body motion detection means to detect the rough body motion which is a motion of the body, and a count calculation means of rough body motion generating to compute the count of rough body motion generating from the detection result of said rough body motion detection means, It had a heart rate detection means to detect the heart rate of the body, a heart rate fluctuation calculation means to compute fluctuation of a heart rate from the detection result of said heart rate detection means, and a sleep period detection means to detect the sleep period of said body from the output of said count calculation means of rough body motion generating, and the output of said heart rate fluctuation calculation means.
[0029] And since two fluctuation with correlation to the count of rough body motion generating, a sleep period called a heartbeat fluctuation generating period, and a sleep period are detected, a sleep period is easily detectable.
[0030] Moreover, the sleep period detection equipment concerning claim 11 of this invention computes the count of rough body motion generating from the number of the rough body motions which the count calculation means of rough body motion generating generated in the time amount more than for at least 30 minutes.
[0031] And since a rough body motion is detected using the high time interval of the probability for a rough body motion to occur and it considers as 1 time of data even when sleep depth is deep, an intermittent output is efficiently convertible for analog data.
[0032] Moreover, a sleep period detection means detects fluctuation of 1 hour to two time periods from the output of the count calculation means of rough body motion generating, and makes a sleep period the sleep period detection equipment concerning claim 12 of this invention.
[0033] And since fluctuation equivalent to the sleep period generally called 1-hour and half extent is detected and it considers as a sleep period, the fluctuation which synchronizes with a sleep period is certainly detectable.
[0034] Moreover, a sleep period detection means detects the fluctuation period of 1 hour to two time periods from the output of a heart rate fluctuation calculation means, and uses the sleep period detection equipment concerning claim 13 of this invention for calculation of a sleep period.
[0035] And since the fluctuation which synchronizes with a sleep period among heart rate fluctuation is detected and a sleep period is determined, an easy and exact sleep period can be determined.
[0036] Moreover, the sleep period detection equipment concerning claim 14 of this invention is used for detection of a sleep period after removing the output at the time of a rough body motion detection means detecting generating of a rough body motion among the detection results of a heart rate detection means.
[0037] And since only the data at the time of there being no rough body motion generating in detection of a sleep period are used, a sleep period can be detected correctly, without using the unreliable heart rate at the time of rough body motion generating.
[0038] Moreover, the sleep period detection equipment concerning claim 15 of this invention has a body detection means to detect the body, and a heart rate detection means and a rough body motion detection means perform heart rate detection and rough body motion detection, only when the body detection means has detected the body.
[0039] And since detection of a heart rate or a rough body motion is performed only when the body exists, a sleep period can be detected certainly, without being influenced by temporary vibration from other than the body.
[0040] Moreover, it has a hypnagogic detection means, said hypnagogic detection means is decided beforehand after detecting hypnagogic, and the sleep period detection equipment concerning claim 16 of this invention is restricted within **** time amount, and detects deep non-REM sleep.
[0041] And since it restricts to the predormitum in which the deep non-REM sleep of the sleep depth 3 or 4 appears and deep non-REM sleep is detected, the deep non-REM sleep of the predormitum is certainly detectable.
[0042] Moreover, it has a hypnagogic detection means, said hypnagogic detection means is decided

beforehand after detecting hypnagogic, and the sleep period detection equipment concerning claim 17 of this invention is restricted after **** time amount, and detects REM sleep.
[0043] And since REM sleep restricts to the anaphase of the sleep which appears mostly and generally detects REM sleep, the REM sleep of the anaphase of sleep is certainly detectable.
[0044]
[Example] Hereafter, the example of this invention is explained using a drawing.
[0045] (Example 1) Drawing 1 is the block diagram of the sleep period detection equipment in the example 1 of this invention. The sway sensor which detects various vibration from a fine vibration of the heartbeat of the body with which one in drawing had been arranged at the futon and 2 has been arranged at the futon 1 bottom, or breathing to the rough body motion by motion of the bodies, such as changing sides and migration of the limbs, A signal-processing means to remove an unnecessary frequency component while 3 amplifies the output signal of a sway sensor, An amplitude calculation means by which 4 computes the amplitude of the output of the signal-processing means 3, a body detection means by which 5 detects existence of the body on a futon 1 from the output of the amplitude calculation means 4, A rough body motion detection means by which 6 detects only the rough body motion by motion of the body from the output of the amplitude calculation means 4, A count calculation means of rough body motion generating for 7 to detect the count of rough body motion generating from the point in time to [from the output of a rough body motion detection means] 30 quotas, and to output, A count fluctuation calculation means of rough body motion generating by which 8 computes fluctuation of the count of rough body motion generating from the output of the count calculation means 7 of rough body motion generating, A heart rate detection means for 9 to extract the fluctuation component by the heartbeat from the output signal of the signal-processing means 3, and to detect a heart rate, A heart rate fluctuation calculation means by which 10 computes heart rate fluctuation from the output of a heart rate detection means, A hypnagogic detection means by which 11 opts for hypnagogic from the output of the body detection means 5, the output of the rough body motion detection means 6, and the output of the heart rate detection means 9, A sleep period detection means by which 12 determines a sleep period from the output of the body detection means 5, the output of the count fluctuation calculation means 8 of rough body motion generating, the output of the heart rate fluctuation calculation means 10, and the output of the hypnagogic detection means 11, and 13 are a display means to display the sleep period which the sleep period detection means 12 detected.
[0046] Using a piezoelectric device, a sway sensor 2 generates the charge according to the magnitude of vibration, when a mechanical vibration is added, and it is arranged here at the futon 1 bottom. Moreover, the bottom of a sway sensor 2 serves as a tatami 14. Moreover, the signal-processing means 3 consists of magnification means 3a which amplifies the output of the biomedical signal detection means 2, and filter 3b which removes unnecessary signalling frequency.
[0047] Moreover, with the heart rate fluctuation calculation means 10, only when, as for the rough body motion detection means 7 and the heart rate detection means 9, the body exists on a futon 1 using the output of the body detection means 5 by trying not using the heart rate detected using the output of the rough body motion detection means 6 at the time of rough body motion generating for calculation of heartbeat fluctuation, detection of a rough body motion or a heart rate is performed.
[0048] An operation of the above-mentioned configuration is explained. The output Fig. of the amplitude calculation means 4 is shown in drawing 2 . If the body is implanted on a futon 1 and becomes or sits down horizontally, the sway sensor 2 arranged in the futon 1 bottom will vibrate, and the electrical potential difference according to the magnitude of vibration will be generated. As shown in drawing 2 , the signal in the case of the rough body motion to which the signal by fine body motions, such as a heartbeat of the body and breathing, continues, and it appears, and (B) and changing sides will be carried out, or an arm and a foot will be moved if the body is making it the rest with bigger (A) in which a big signal appears temporarily by the impact at the time of implantation at the time of implantation than the case of a fine body motion appears to this generating signal temporarily (C). If the body is not, an output signal becomes small and approaches zero (D).
[0049] On the other hand, at the moment of an object being placed, when an object is put on a futon 1, since the fine fine body motion by the heartbeat or breathing like the body does not have (E) in

which a big signal appears temporarily in an object, an output signal approaches zero again (F). Moreover, also when people walk on a futon 1 and pass, it becomes being the same as that of the case where an object is placed.

[0050] By using V1 shown in drawing as a threshold which divides the case where it does not exist with the case where the body exists, the existence of the existence of the body is detectable by measuring the output of the amplitude calculation means 4 with this V1. Magnification means 3a of the signal-processing means 3 amplifies the output signal from such an oscillating sensor 2, and filter 3b removes an unnecessary frequency component, and is outputting it to the amplitude calculation means 4 and the heart rate detection means 9.

[0051] The amplitude calculation means 4 computes the amplitude of the output signal of the signal-processing means 3, and is outputting it to the body detection means 5 and the rough body motion detection means 6. With the body detection means 5, the existence of the existence of the body on a futon 1 is judged based on the description of the signal at the time of lying in bed as shown in drawing 2 . This judgment algorithm is shown in drawing 3 .

[0052] A power source is switched on (ST1), it is not rich, T1 is set to a timer (ST2), and it starts from the judgment of "people exist temporarily" (ST3). The judgment is changed into "**" only after are in the condition which is not trustworthy although it is suspected that people exist saying "people exist temporarily", it makes this judgment surely go through when changing a judgment into "**" from an "absence", and judging that it certainly exists. By this, even if a noise and a temporary output occur, it does not become a "**" judging, but positive body detection is attained. By the time it will be decided to "**" if the condition beyond V1 continues until a timer is set to 0 (ST6), and a timer is set to 0, once it will be in the condition not more than V1 as compared with the threshold V1 which was able to opt for the output of the amplitude calculation means 4 beforehand, reducing the timer after a start, it will be decided (ST15) at an "absence" (ST4, ST5).

[0053] When "**" was decided, and time amount of "being ** temporarily" is also made into "**" (ST7, ST9) and is decided by "**" from "it is an absence temporarily", the time amount of "being an absence temporarily" is also returned to "**" (ST8), and this condition is maintained until it detects that the output of the amplitude calculation means 4 becomes less than [V1] (ST10).

[0054] If the output of the amplitude calculation means 4 becomes less than [V1], T2 will be set to a timer (ST11), and an absent judging will be performed as (ST12) as "being an absence temporarily." Once the judgment of an "absence" will become more than V1 by the time it decides in an "absence" (ST15) and a timer is set to 0 when the time amount from which the output of the amplitude calculation means 4 becomes less than [V1] continues two or more [T] from "**", it will be decided to "**" (ST13, ST14). (ST6) Time amount which became "being an absence temporarily" from "it is an absence temporarily" when it was decided at an "absence" is also made into an "absence" (ST16, ST18). This condition is maintained until it detects becoming when an "absence" being decided from "it is ** temporarily" more than [it also returns the time amount of "being ** temporarily" to an "absence" (ST17) and the output of the amplitude calculation means 4 shows the big body motion of the body at the time of an ON floor] V2 (ST19). and the case where the output of the amplitude calculation means 4 becomes more than V1 -- a timer -- T1 -- a set (ST20) -- carrying out -- again -- as "being ** temporarily" -- as (ST3) -- "**" and an "absence" -- that judgment is performed.

[0055] ** of the body on this futon 1 and an absent judgment are outputted to the rough body motion detection means 6, the heart rate detection means 9, the hypnagogic detection means 11, and the sleep period detection means 12. When the body detection means 5 has detected that the body exists on a futon 1, the rough body motion detection means 6 detects only big rough body motions, such as changing sides, on the ON floor of the body from the output of the amplitude calculation means 4 to a futon 1, bed leaving, or a futon 1, and is outputting them to the count calculation means 7 of rough body motion generating, the heart rate fluctuation calculation means 10, and the hypnagogic detection means 11.

[0056] In addition, since it considers as the rough body motion of the body with the rough body motion detection means 6 only when [to which the body detection means 5 is on a futon 1 as for the body] thing detection is being carried out Even when people approach near the futon 1 when the body does not exist on a futon 1, or you walk on a futon and a big output comes out from a sway

sensor 2, it can prevent performing hypnagogic detection which has recognized this to be a rough body motion incorrect, and mistook it, and sleep period detection.
[0057] When the body detection means 5 detects that the body exists on a futon 1, the heart rate detection means 9 extracts the signal from 0.5Hz to 2Hz from the output of the signal-processing means 3 with a filter, computes a heart rate in quest of the period of this signal, and is outputting it to the heart rate fluctuation calculation means 10 and the hypnagogic detection means 11. Although the heart rate fluctuation calculation means 10 computes the magnitude of fluctuation of a heart rate in quest of the distribution for 5 minutes of the heart rate detection means 9 and being outputted to the sleep period detection means 12 From the heart rate detection precision of a heart rate detection means 9 by which the output signal of the signal-processing means 3 blurs greatly, and is computing the heart rate using the periodicity of the output of the signal-processing means 3 falling, at the time of rough body motion generating After removing the data of the heart rate computed using the output of the signal-processing means 3 at the time of a rough body motion occurring using the output of the rough body motion detection means 6, the distribution for 5 minutes is computed, the heart rate fluctuation which is not influenced by the rough body motion is computed, and it is outputting to the sleep period detection means 12. Here, since the heart rate of the body is detected only when [to which the body detection means 5 is on a futon 1 as for the body] thing detection is being carried out, it can prevent performing hypnagogic detection which did not compute a heart rate by force in the condition that there is no signal of the body, and was mistaken using this, and sleep period detection.
[0058] The hypnagogic detection means 11 is performing hypnagogic detection of the body on a futon 1 from the output of the rough body motion detection means 6, and the output of the heart rate detection means 9, when the body detection means 5 has detected that the body exists on a futon 1. The hypnagogic detection principle of this hypnagogic detection stage is explained using drawing 4 . It is the sleep phase where the heart rate for 1 minute was judged for drawing 4 (a), and the generating situation of a rough body motion and drawing 4 (c) were judged for drawing 4 (b) from results, such as an electroencephalogram. In addition, in the notation of the axis of ordinate of drawing 4 (c), W shows recovery and, as for REM sleep and the figure of 1-4, R shows the sleep depth of non-REM sleep.
[0059] Although hypnagogic [of the inside A of drawing] was carried out from recovery and it was judged with the sleep depth 1, it is the part judged after 5 minutes again to be recovery, and B is the part which carried out hypnagogic from recovery, progressed to 4 gradually from the sleep depth 1, and went into deep non-REM sleep. If a heart rate will fall quickly while being judged with the sleep depth 1 in A if change of the heart rate of drawing 4 (a) is seen here, and it is again judged with recovery after 5 minutes, the heart rate rose again and has returned to the level at the time of recovery of A. On the other hand, although a heart rate falls to hypnagogic and coincidence in B, even if sleep depth is set to 4 from 1, the level with the low heart rate after the heart rate immediately after hypnagogic falls is maintained. Thus, if the heart rate at the time of hypnagogic falls rapidly and returns from a hypnagogic state to recovery when shifting to hypnagogic from recovery, it will rise on the original level quickly.
[0060] Moreover, if drawing 4 (b) is seen, A front and after B, the rough body motion will be generated, when sleep depth changes from 4 to R, and generating of a rough body motion will not be seen before and after hypnagogic. A rough body motion seldom generates this before and after hypnagogic, and if sleep depth becomes [the deep non-REM sleep of the sleep depth 4] being easy to be discovered immediately after hypnagogic deeply, since most generating of a rough body motion is lost, a rough body motion will not generate it over long duration in many cases immediately after hypnagogic.
[0061] At this example, by then, the case where generating of a rough body motion does not occur beyond T3 time amount from the output of (1) rough body motion detection means 6 And it detects that the heart rate fell one or more C between them [(2)], judges with the body on a futon 1 having carried out hypnagogic, when the level which fell (3) heart-rate fall beyond after [detection] T-four time amount was being maintained, and is considering as hypnagogic time of day with the time of a heart rate falling one or more C.
[0062] or [in addition, / that recovery continues when there is no change of a heart rate long

duration, since one of the change of recovery from hypnagogic or hypnagogic comes out from recovery clearly in our experiment in many cases although it turns out that individual difference has change of the heart rate at the time of hypnagogic] -- or it is considered that it is either whether hypnagogic would be carried out and it would be in the sleep state. It can judge whether it is in which condition by the existence of a rough body motion. Therefore, even when the heart rate change at the time of hypnagogic cannot detect the fall of the heart rate of (2) among little above, it can detect hypnagogic certainly from (3) to (1), a heart rate, and a rough body motion. However, since hypnagogic time of day does not become clear in this case, it is supposed after hypnagogic detection that it carried out hypnagogic after fixed time amount T four beforehand decided to be the last from the time of a body motion occurring. In addition, in this example, T four is set up as 15 minutes.

[0063] With the count calculation means 7 of rough body motion generating, when the output of the body detection means 5 has detected that the body exists, the count of the rough body motion generated by 30 quotas from the time is counted. Although this increases when it may have been 30 minutes or more in the time when the recurrence interval of the rough body motion under sleep is long and this has become deep non-REM sleep, it is for clarifying periodicity, as swing width of face of an output is enlarged by making the output of a count such even case into zero as much as possible.

[0064] The output at the time of changing the time amount counted in the count calculation means 7 of rough body motion generating to drawing 5 is shown. When the rough body motion to which the rough body motion detection means 6 detected drawing 5 (a), and the time amount which drawing 5 (b) counts are for 15 minutes, in for 30 minutes, drawing 5 (d) of drawing 5 (c) is a case for 45 minutes. It turns out that drawing 5 (c), (d), and time amount take for extending, the flat part of the count 0 of a rough body motion which appears here and there by drawing 5 (b) is lost gradually, and the wave of a long period is also clear while the flat part is lost although a flat part stops existing in drawing 5 (d). Although drawing 5 is an example, it is thought desirable to count the count of a body motion more than for 30 minutes from our old examination result. The body motion output which this generates intermittently is efficiently convertible for analog data. However, since the period of sleep is generally 30 minutes per hour [about], the time amount to count needs to be shorter than 30 minutes per hour enough.

[0065] Thus, the count calculation means 7 of rough body motion generating takes out fluctuation of the long period of a rough body motion, fluctuation of the period of 1 to 2 hours when the count fluctuation calculation means 8 of rough body motion generating is equivalent to a sleep period is detected further, and it is outputting to the sleep period detection means 12. In addition, the output of the count fluctuation calculation means of rough body motion generating is also correlated with a sleep period, can come, and can know the outline of a sleep period also with a chisel.

[0066] A sleep period is computed from the output of the count fluctuation calculation means 8 of rough body motion generating until it is judged with having carried out bed leaving of the sleep period detection means 12 with a back body detection means by which hypnagogic [of the body] was detected by the hypnagogic detection means 11, and the heart rate fluctuation calculation means 10. It explains using the conceptual diagram 6 of this calculation.

[0067] The sleep period to which the output of the heart rate fluctuation calculation means 10 detected the output of the count fluctuation calculation means 8 of rough body motion generating and (b), and, as for drawing 6 (a), the sleep period detection means 12 of this example detected (c), and (d) are as a result of [of the sleep depth by an electroencephalogram etc.] a judgment. In addition, the shallow non-REM sleep by which REM sleep and a figure are equivalent to the sleep depth of non-REM sleep, and NR12 is [W / recovery and R] equivalent to the sleep depth 1 or 2, and NR34 express the deep non-REM sleep equivalent to the sleep depth 3 or 4 among drawing.

[0068] First, considerable, then the field considered are extracted from the output of the count fluctuation calculation means 8 of rough body motion generating, and the output of the heart rate fluctuation calculation means 10 to deep non-REM sleep. Since in the case of the deep non-REM sleep of the sleep depth 3 or 4 there is the description that little fluctuation of a heart rate is and it generates mainly within 3 hours after hypnagogic mostly [the count of rough body motion generating in fixed time amount] The output of the count fluctuation calculation means of (1) rough

body motion generating detection of deep non-REM sleep Less than [M1], (2) It judges that the case where the output of the heart rate fluctuation calculation means 10 fulfills both three conditions of generating ** within 3 hours after two or less C and (3) hypnagogic detection means 11 detecting hypnagogic is the deep non-REM sleep of the sleep depth 3 or 4.

[0069] Next, REM sleep is detected. Here, in REM sleep, it used that the count of rough body motion generating in that fluctuation of a heart rate becomes larger than the time of non-REM sleep and fixed time amount increased, and the big part of heart rate fluctuation was extracted from fluctuation of a heart rate, and when the count of rough body motion generating of the part is larger than a threshold, REM sleep is detected. Moreover, since short **** and the case where it does not appear as heart rate fluctuation clearly have appearance time after hypnagogic for about 3 hours, as for REM sleep, it is desirable to detect REM sleep after after [hypnagogic] 3 hour. Therefore, the output of three or more C and the count fluctuation calculation means of (2) rough body motion generating has judged [the output of (1) heart-rate fluctuation calculation means 10 / more than M2 and (3) hypnagogic detection means 11] that hypnagogic is REM sleep when fulfilling both three conditions of generating ** after after [detection] 3 hour here.

[0070] In addition, after extracting the fluctuation which is equivalent to the period of REM sleep by carrying out wave filtration of the signal of the period of 1 to 2 hours with a filter, and taking it out from the output of the heart rate fluctuation calculation means 10, the above-mentioned REM sleep is detected here. It is also possible to use only this fluctuation as an index with an easy sleep period reflecting the description of a sleep period.

[0071] Thus, it can ask for a sleep period like drawing 6 (c) from hypnagogic [which was extracted] by unifying the part of the deep non-REM sleep of less than 3 hours, and the part of the REM sleep after [hypnagogic to] 3 hour. Although a difference is in a fine point as compared with a sleep depth judging according this to the electroencephalogram of drawing 6 (d) etc., it turns out that the outline conforms.

[0072] In addition, this fluctuation may be evaluated and you may judge whether it is the right as a sleep period. For example, it can judge based on three points of whether the sleep period (1) Obtained is repeated the regular period of 1.5 to 2 hours, it correlates with the count fluctuation of (2) rough body motion generating, or to correlate with (3) heart-rate fluctuation period. In (1), frequency analysis of the sleep period is carried out, and it can judge with the peak of the frequency band with which a period corresponds in 2 hours from 1.5 hours using power spectrum density being repeated the regular period of 1.5 to 2 hours as compared with the threshold P1 decided beforehand in the case of beyond P1. Moreover, each wave and cross-correlation are computed about (2) and (3), and if there is correlation when it is the threshold R1 the value of a cross correlation function was beforehand decided to be, and more than R2, it can judge, respectively. In addition, when it turns out for all not to be right by this judgment, it is also possible to change each threshold again and to redo calculation of a sleep period. Thereby, detection of an exact sleep period is realizable.

[0073] Moreover, it can also ask for a more exact sleep period combining the fluctuation wave of the count fluctuation calculation means of rough body motion generating, and the fluctuation wave of a heart rate fluctuation calculation means. Although the description of the non-REM sleep in the first half of sleep becomes clear with the output of the count fluctuation calculation means of rough body motion generating, the sleep period of the second half becomes unstable, and with the output of a heart rate fluctuation calculation means, conversely, under the effect of REM sleep, since fluctuation with the clear one more extensive than the first half tends to appear, both advantage can be utilized effectively, and the outline of a more exact sleep period can be acquired.

[0074] Thus, since the sleep period detection equipment of this example detects a sleep period combining independent or both in quest of the generating period of a rough body motion with a sleep period and correlation, or heart rate fluctuation in which, it can detect the outline of a sleep period easily.

[0075] Moreover, since the sleep period detection equipment of this example can detect each sleep phase using the description of deep non-REM sleep and REM sleep at the time of hypnagogic from a rough body motion and a heart rate, it can ask for an exact sleep period.

[0076] Moreover, since the sleep period detection equipment of this example detects fluctuation equivalent to the sleep period generally called 1-hour and half extent and makes it a sleep period, it

can detect certainly the fluctuation which synchronizes with a sleep period.
[0077] In addition, although the futon is used as a living body's support means in this example, it may be used for a bed Sagitta seat.
[0078] Moreover, although the signal-processing means consists of a magnification means and a filter in this example, a magnification means is not necessarily required, when the sensibility of a biomedical signal detection means is good and an output can be taken enough, and when the magnitude of a filter of an unnecessary signal component is sufficiently smaller than a biomedical signal, it can do unnecessarily.
[0079] Moreover, although **/absence on a sleep period or a futon are judged in this example as compared with the threshold which was able to determine beforehand time amount, such as V1 and T1, a detection value, etc. in the judgment means, these thresholds are using the optimum value which checked the output and actually asked for it statistically from these data by many men. in addition -- although this threshold may use constant value, while performing detection of a heart rate or a rough body motion -- each time -- changing -- making -- a thing -- **** -- natural -- it is good.
[0080] Moreover, in this example, although the rough body motion and heart rate of the body on a futon are detected using one sway sensor, the configuration using the detection means of respectively different dedication may be used. Moreover, it is also possible to ask not only for a heart rate but for a respiration rate, and to use for detection of a sleep period.
[0081] Moreover, in this example, what detects a big motion of what detects vertical movement of the abdomen of the body which originates in a rough body motion called a motion of the body, and breathing and a heartbeat activity by non-contact with a laser variation meter etc. although a rough body motion and detection of a heart rate are performed using the sway sensor, a delicate change which originates in breathing and a heartbeat activity of the body on bedding by non-contact using a ccd camera etc., and the body may be used.
[0082] Moreover, although the bottom of a futon is covered with the sway sensor in this example, if cushions, such as sponge, etc. are further arranged under a sway sensor, the output to vibration can be enlarged. It is effective when using especially flexible piezoelectric devices, such as PVDF (Pori fluoridation kinky thread NIDEN), as a sway sensor.
[0083] Moreover, although detection of deep non-REM sleep is performed only within less than 3 hours in this example from hypnagogic, this numeric value is set up from the general view that many [within 3 hours] appearances of deep non-REM sleep are seen after hypnagogic. However, after [hypnagogic] 3 hour or subsequent ones may appear, therefore it is not necessary to necessarily limit this detection within 3 hours. Moreover, similarly, although detection of REM sleep is restricted after after [hypnagogic] 3 hour, it is not necessary to necessarily limit here after 3 hour. Furthermore, this example is available for the time domain of detection of deep non-REM sleep, and detection of REM sleep at all, even if both detection field laps, although not overlapped.
[0084] Moreover, although the heart rate fluctuation calculation means is computing and outputting distribution from the heart rate for 5 minutes in this example, the time amount used for calculation of fluctuation is not limited in 5 minutes that what is necessary is just to be for 1 to about 10 minutes. Moreover, as long as it is the count approach that calculation of fluctuation can also compute magnitude of fluctuation, such as standard deviation, not using distribution, what kind of count approach may be used.
[0085] Moreover, although the fluctuation component of 1 hour to two time periods is taken out from the output of the count calculation means of body motion generating, or the output of a heart rate fluctuation calculation means and being used for sleep period detection in this example This is because a sleep period generally has the period of 1-hour and half extent, change, and it moreover changes with the occasional conditions by the individual again, so it can fully respond also to change of such a condition if fluctuation of the period from 1 hour to 2 hours is detectable. However, it is not necessary to necessarily take all of the fluctuation component of 1 to 2 hours out, and what only carried out the moving average of the output of the count calculation means of body motion generating or the output of a heart rate fluctuation calculation means, and removed the noise component can fully be used for sleep period detection.
[0086] As stated to the above-mentioned example, the sleep period detection equipment of this invention can detect the sleep period of the body, without extracting an electroencephalogram, an

electromyogram, and an eye ball lightning Fig. By using this, the actual sleep situation of grasp of an insomniac's sleep state and those who appeal against insomnia can be grasped easily. Moreover, it is also possible to deduce the life rhythm of a proper from a sleep period or the time zone of sleep to men, such as a circadian rhythm, and it can greatly use for instruction of a suitable life to the young man and elderly people to whom a life rhythm tends to be confused, implementation of a vital force **** life, etc.

[0087]

[Effect of the Invention] As mentioned above, as the example explained, according to this invention, the sleep period of the body can be detected, without extracting an electroencephalogram, an electromyogram, and an eye ball lightning Fig. By using this, the actual sleep situation of grasp of an insomniac's sleep state and those who appeal against insomnia can be grasped easily.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The block diagram of the sleep period detection equipment in the example 1 of this invention
[Drawing 2] The output Fig. of the amplitude calculation means of this equipment
[Drawing 3] The flow chart of the body detection algorithm of the body detection means of this equipment
[Drawing 4] (a) The output Fig. of the heart rate detection means at the time of hypnagogic detection of this equipment
(b) The output Fig. of the rough body motion detection means at the time of hypnagogic detection of this equipment
(c) The sleep phase diagram detected using the electroencephalogram at the time of hypnagogic detection etc.
[Drawing 5] (a) The output Fig. of the rough body motion detection means of this equipment
(b) The output Fig. of the count calculation means of rough body motion generating of this equipment
(c) The output Fig. of the count calculation means of rough body motion generating of this equipment
(d) The output Fig. of the count calculation means of rough body motion generating of this equipment
[Drawing 6] (a) The output Fig. of the count fluctuation calculation means of rough body motion generating of this equipment
(b) The output Fig. of the heart rate fluctuation calculation means of this equipment
(c) The output Fig. of the sleep period detection means of this equipment
(d) The sleep phase diagram detected using the electroencephalogram etc.
[Description of Notations]
5 Body Detection Means
6 Rough Body Motion Detection Means
7 Count Calculation Means of Rough Body Motion Generating
9 Heart Rate Detection Means
10 Heart Rate Fluctuation Calculation Means
11 Hypnagogic Detection Means
12 Sleep Period Detection Means

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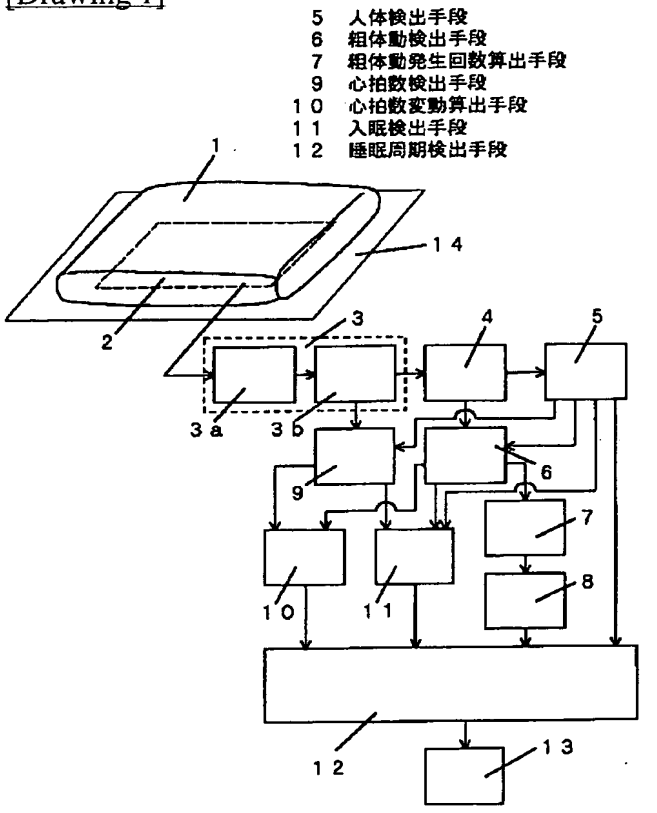
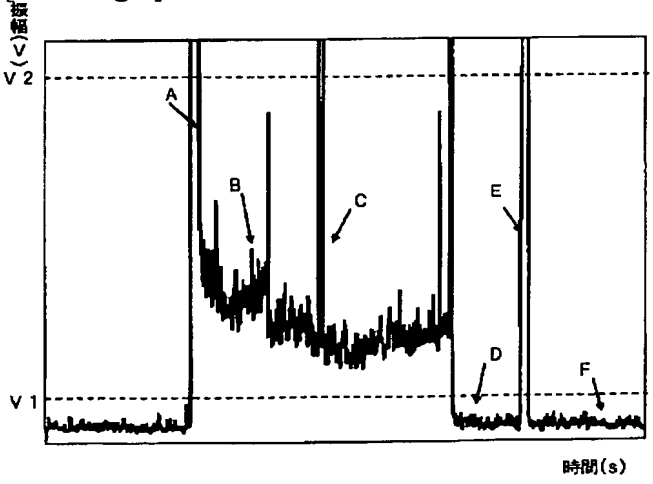
DRAWINGS

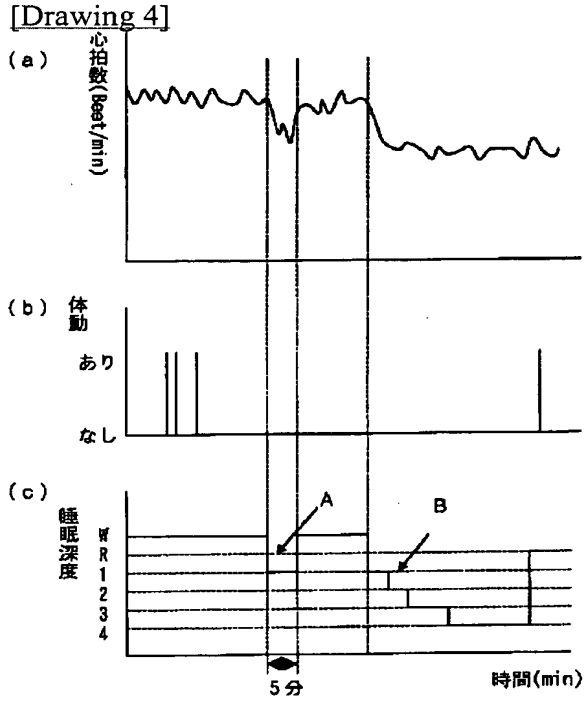
[Drawing 1]



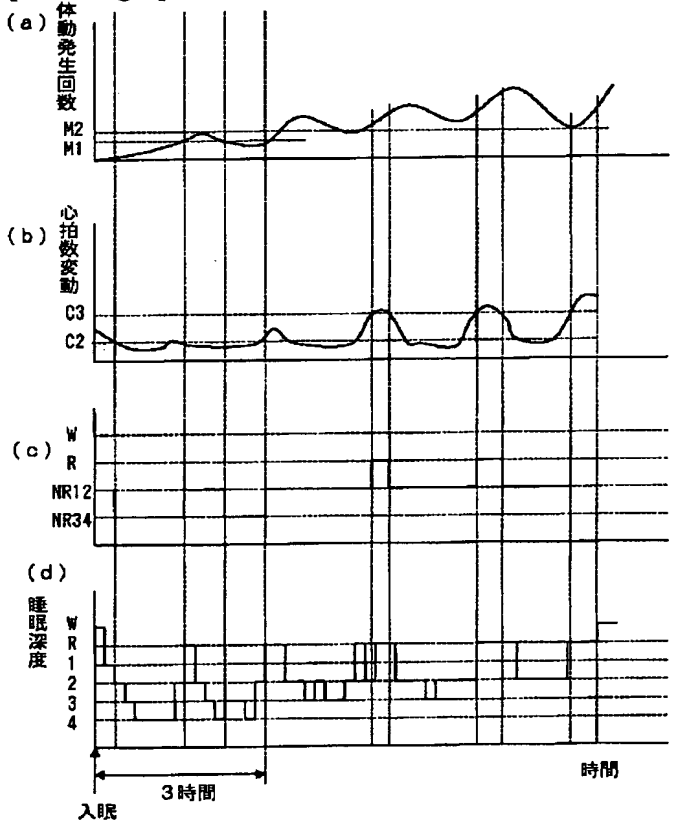
[Drawing 2]



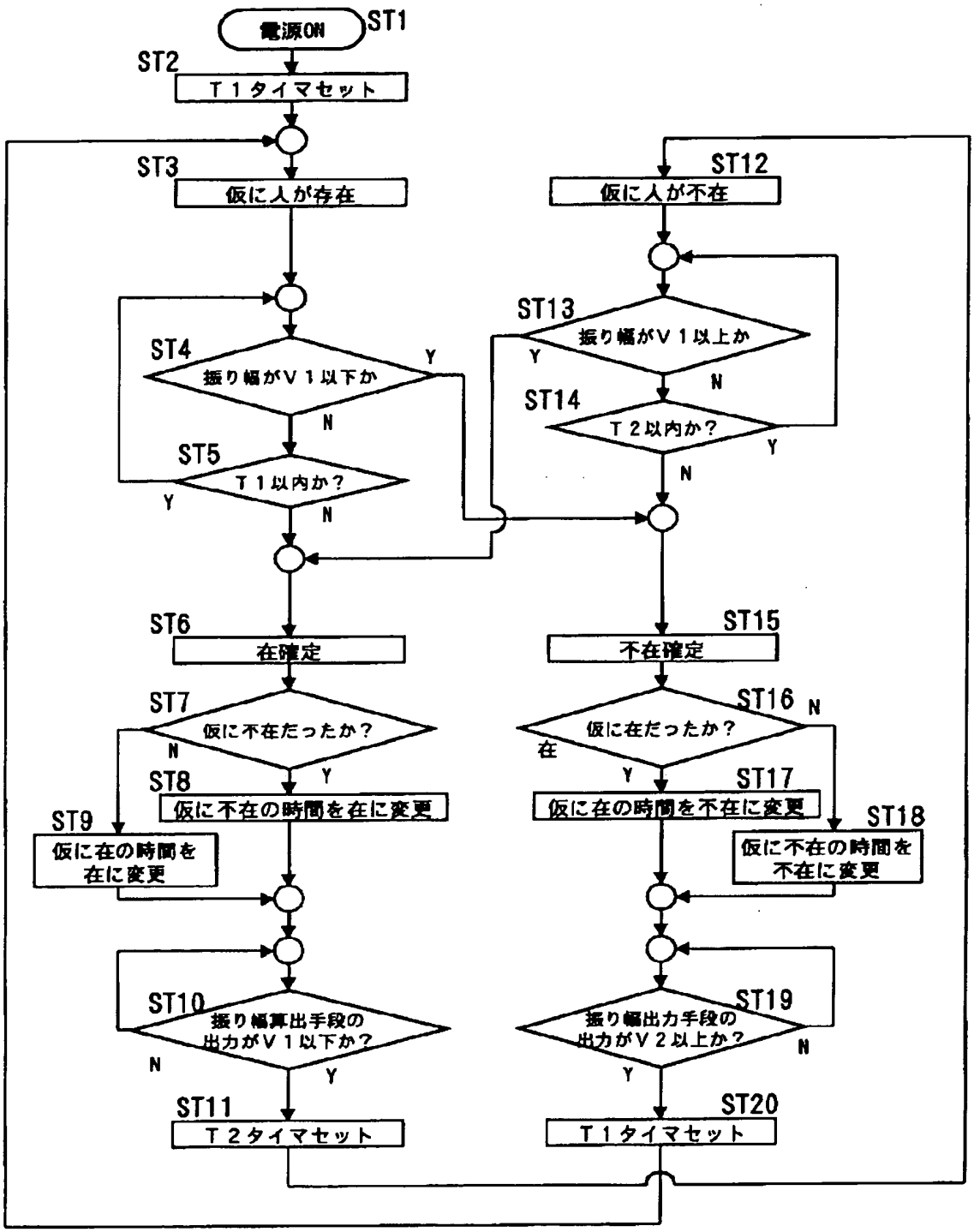
[Drawing 4]



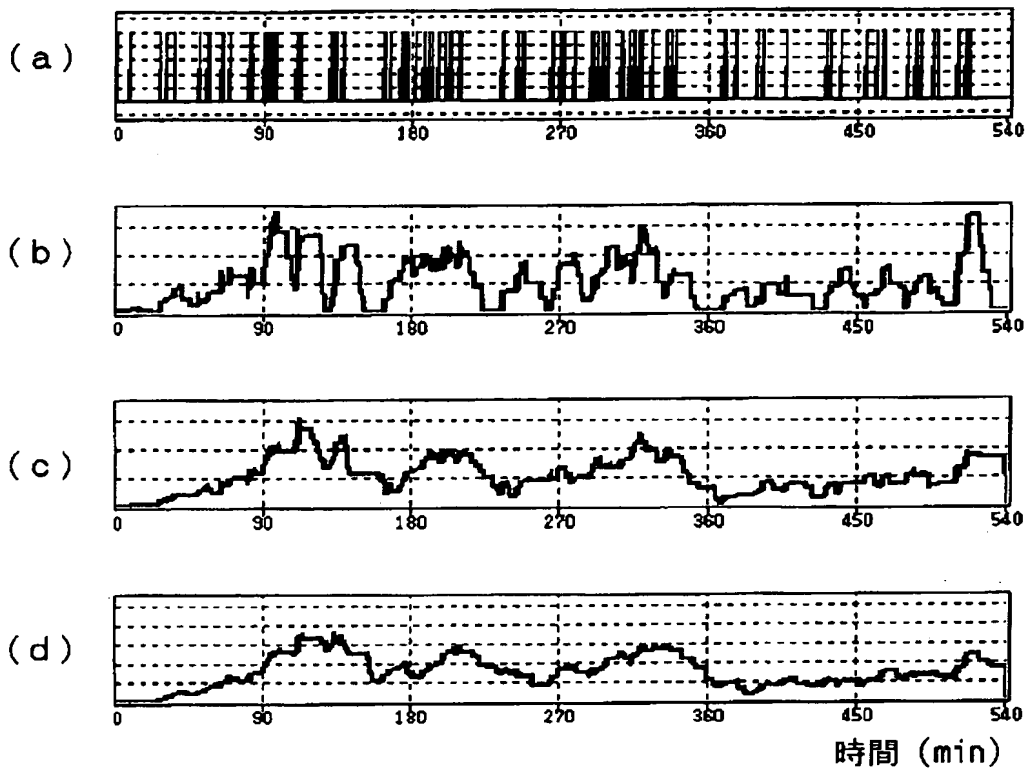
[Drawing 6]



[Drawing 3]


電源ON
ST1
ST2
Ｔ１タイマセット
ST3
仮に人が存在
ST4
振り幅がＶ１以下か
Y
N
ST5
Ｔ１以内か？
Y
N
ST6
在確定
ST7
仮に不在だったか？
N
Y
ST8
仮に不在の時間を在に変更
ST9
仮に在の時間を
在に変更
ST10
振り幅算出手段の
出力がＶ１以下か？
N
Y
ST11
Ｔ２タイマセット
ST12
仮に人が不在
ST13
振り幅がＶ１以上か
Y
N
ST14
Ｔ２以内か？
Y
N
ST15
不在確定
ST16
仮に在だったか？
N
在
Y
ST17
仮に在の時間を不在に変更
ST18
仮に不在の時間を
不在に変更
ST19
振り幅出力手段の
出力がＶ２以上か？
N
Y
ST20
Ｔ１タイマセット

[Drawing 5]



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